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West Europe Report

SCIENCE AND TECHNOLOGY

No. 1

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This report contains information on national-level science policies, technology strategies, and research and development programs in West European science and technology in general and specifically in civil technology, with particular attention to transportation, energy, chemical manufacturing, industrial automation and technology transfer. The report will focus primarily on France and the Federal Republic of Germany, but will also cover important developments in Italy, the Netherlands, Sweden and other West European countries.

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SCIENCE AND TECHNOLOGY

No. 1

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RESULTS OF UN TECHNOLOGY DEVELOPMENT CONFERENCE REPORTED

Paris AFP SCIENCES in French 6 Sep 79 pp 3-4

[Text] VIENNA--The Vienna action program. After 2 weeks of work conducted in the Austrian capital from 20 to 31 August, following almost 3 years of preparatory meetings and work, the Science and Technology Development Conference ended with the adoption of an action plan, to be known hereafter as "Vienna Action Plan," which, subject to UN General Assembly approval, contemplates a number of means intended to promote R & D for the developing countries.

The two most concrete proposals adopted not without difficulty after acrimonious discussions and many compromises, relate to the creation of an Intergovernmental Committee and an Interim Fund.

The task of the Intergovernmental Science and Technology Development Committee will be to coordinate the sceintific and technological activities in the UN system. As full-share members all the states are invited to participate, and the committee will meet annually and present its reports and recommendations to the UN General Assembly through the Economic and Social Council (ECOSOC). This item has been the subject of animated controversy since most of the industrialized countries wanted the Committee to report to ECOSOC, while the Group of 77, comprising the 121 countries of the Third World, insisted on direct connections between the committee and the General Assembly.

The Intergovernmental Committee may invite intergovernmental orgainzations, nongovernment organizations (the NGO's), and other appropriate organizations to participate in its work. The services of a secretariat with a high-level chief should be available to assist the director general for international development and economic cooperation (No 2 in the UN hierarchy) in supplying the desired help to the Committee. The Interim Fund is intended to release new resources to finance R & D programs in developing countries. The Group of 77 had desired the creation of a permanent fund of $2 billion in 1985 and $4 billion in 1990, maintained by compulsory contributions of the developed countries, to be assured of regular financing which would have been controlled by the Intergovernmental Committee. Opposition to the creation of a fund in this form was strong, and finally the formula of an Interim Fund maintained by voluntary contributions was adopted.

For the 2 years 1980 and 1981 the total amount thereof has been fixed at at least $250 million. However, were the entire sum to be appropriated for specific programs an addition could be discussed.

Until a final financial mechanism is established the Interim Fund will be administered by the United Nations Development Program in accordance with general instructions to be established at the 34th Session by the General Assembly, and with guiding principles to be determined at the meetings of the Intergovernmental Committee.

The Vienna Action Program also specifies a number of principles and resolutions constituting a true charter covering the desired relations between developed and developing countries to place science and technology in the service of development (national science policies, evaluation, selection and program control strcutures, education and training of research and technical personnel, action to prevent the emigration of competent persons, scientific and technological dissemination, encouragement of creativity and innovation, etc., including the establishment of national and international scientific and technological networks).

In contrast, this program includes no decision on technology transfer or transnational companies, since no agreement has been reached on this matter.

The conclusion of the UN S & T development conference has been received generally as a measure of victory for the countries of the Third World, and certainly as a resumption of the North-South dialog.

Speaking in the name of the Group of 77, Mr Mahmoud Mestiri, permanent representative of Tunisia at the UN, considered that the conference "had produced incontestable positive results," and that "Vienna had made possible an important step toward North-South cooperation." Mr Theodore M. Hesburgh, head of the US delegation, also appeared to be rather optimistic as he stated that the conference must contribute to "the establishment of a better world," and that "the impulse given should be maintained."

The repersentative of China, who had been especially reserved during the entire conference, considered also that the conference had produced "a number of concrete results." Mr Pierre Aigrain, secretary of state for research with the French delegation, decided that the "results were realistic. Now the outlines established must be filled."

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CSO: 3102

EC SEMINAR PAPERS ON R&D EVALUATION ANALYZED

Paris LE PROGRES TECHNIQUE in French No 13, 1979 pp 14-17

[Article by Georges-Michel Chevallier, lecturer at the Technological University of Compiegne, on assignment to the Directorate of Physical Sciences for Engineers of the CNRS National Center for Scientific Research]

[Text] The European Communities Commission is, on the one hand, concerned with justifying the activities of the European research centers under its jurisdiction, and on the other hand, with specifying the modes of operation of community decision making bodies which exercise surveillance over research jointly financed by the nine countries of the [European Economic] Community. It was for the purpose of contributing elements for reflection that the General Directorate for Research, Science and Education, in June 1978 organized a seminar in Copenhagen on "the evaluation of research and development."

Seventeen communications cited as references were presented to the 55 participants, seven of them French, and we give here an analysis of the 360 pages which resulted.

What Is Understood by "The Evaluation of Research and Development?"

The first lesson learned from this seminar is establishing the diversity of interpretation of this caption without dwelling upon the definition of the words "research" and "development."

For some [10, 11, 17], to evaluate is to find a method of choosing among several scientific programs, whether it is desired to attain certain specific objectives, or whether a like result is sought at lowest cost. A variation consists of interpreting the word "evaluate" in the sense of appraising the cost of a research program and to show, in accordance with as complete a balance sheet as possible, the gain or loss resulting from such research activity[9, 12]. It is indeed clear that here the just definition is found again for only gainful programs will be adopted; however, in certain cases there is an aspect of a posteriori control.

For others [13, 2] it is a matter above all of evaluating the results and the effectiveness of the investigators using quality indicators, what counts being less a program than its success.

For most,[5, 14, 6, 15] it is necessary to combine all these aspects, that is: evaluate objectives and programs before and during activity; and evaluate the results at the conclusion of activity.

Last, a single participant[16] believed it necessary to enter into the more sociological aspect, dear to Americans, of "technological assessment." It must be acknowledged that he confined himself to evaluation of development projects.

Considering the diversity of situations in which evaluation may be undertaken (basic research, applied research, development, and so forth, at the national level or laboratory level, or within the realm of science) the complexity of providing a synthesis as objective as possible in a few pages can be surmised. Moreover, it is to be regretted that we do not know what took place in discussions planned during the course of the seminar which would have supplemented the written contributions.

Evaluation of Objectives and Programs

A concept often advanced[15, 16]...is to distinguish between program and project. A program corresponds to an ensemble of research endeavors aimed at a rather general objective; it is subdivided into projects at the laboratory level.

At the project level there is evaluation with choice of this or that proposal with control of projects while under way or upon completion.

At the program level there is evaluation with definition of objectives and their tactical exploitation within the scope of a program plan.

To commence evaluation, methods more or less quantitative can be applied [6, 7, 17]: methods of ranking priorities, methods of scoring (several parameters are selected and recorded before deriving a total and then a rating), method of risk analysis, and so forth.

The top step in the scale of complexity is to use mathematical program models or a modification of the PERT method which is called GERT (Graphical Evaluation and Review Technique)[6].

The American industrial practice is now in process of evolving toward abandonment of these methods which do not seem to have been used in France*[10]: "garbage in, garbage out." On the contrary, it is sought to evaluate the risk and uncertainty and internal inter-relationships of the project.

* See report by G. M. Chevallier: "Views of the 1978 Session of CEPRIG," published in LE PROGRES TECHNIQUE, No 10.

Toward this end, numerous participants[1, 2, 11]... made reference to the PEER method, judgment by peers, developed by the NSF [National Science Foundation?][6] (but is this really much different from the ATP [expansion unknown] Committees of the CNRS?)

"In order to assist in defining program objectives and making budgetary allocations the NSF organizes frequent symposiums. Eminent scientists are invited to provide papers in their specialties. Both results of individual research and wider range program analyses are presented to them. The participants are supposed to provide the NSF with a restrospective critique, suggesting changes in effort intensity, promising areas, and areas which it is appropriate to abandon. On the whole, if NSF programs operate well, it is because of the excellence of the program directors. The directors are generally experienced investigators who have profound knowledge of their specialties, people working in the same field, and political life."

As soon as a project is received it is subjected to a summary evaluation by an NSF team. If it passes the preliminary test the proposal is submitted to a number of experts--this is the "peer review method." These experts provide the NSF with a commentary and it is the NSF program director concerned who makes the final decision: a project having to be financed or evaluation of the results of a completed project.

According to[6] the great fault with this method is that it promotes formation of an academic oligarchy which, by favoring its own concepts of research, limits the possibilities for original research directions.

Along the same lines are found the procedures of the Atomic Energy Research Center of Great Britain[10] and the Institute for Promotion of Scientific Research in Industry and Agriculture (IRSIA) of Belgium.[11]

It having been noted that very sophisticated quantitative evaluation programs would not be suitable, notably because they do not appear credible to scientists, project evaluation at Harwell is effected in accordance with a rather simple rating screen[10]:

political (internal strategy, coordination with exacting activities, reaction of industry, reaction of public establishments, establishment image, legality, and effects upon the environment);

financial aspect (total market value, maximum capital invested, annual worth to the establishment, length of life, and rate of return);

technical aspect (number of problems to be resolved, degree of difficulty, predictability, existence of technical data, understanding of the system of utilization, availability of staff, and experience and motivation of staff); and

market (knowledge of market. identification of customers, requirements, advantages of new product, protection, length of life, availability of associated manufacturer, and so forth).

Some points are justifiable only in the case of an innovation.

At the IRSIA[11], although the rating is not so strict as at Harwell, there is a list of criteria for selection which is adaptable, depending upon the degree of scientific maturity of the disciplines and the magnitude of the resources to be used:

scientific and technological merit of the program;

scientific competence of the investigators;

general scientific infrastructures of the laboratory;

economic value of the expected results;

assurance that the enterprise or sector is capable of undertaking the financial burdens which will enable the research to be successfully carried out;

capability to elaborate an industrial exploitation strategy for the results in the interests of the national economy; and

contribution of the contemplated developments to the general welfare.

In the industrial sphere the criteria are slightly different.[11]

The complete investigation of each file is performed by scientific personnel of the institute who submit it to a board of independent experts.

Then the administrative council, which includes university professors, industrialists and representatives of the salaried workers, decides.

At the Harwell Atomic Energy Research Center project evaluation is internal but the British Government has just decided that acceptance and financing will henceforth be decided by an outside council ("Requirement Board").

An analogous system is in effect in the Federal Republic of Germany[15] with variations depending upon the institutions performing the research: universities, where only a portion of the activity (20 percent) of projects is financed; institutes, where efforts are made to determine, essentially, the costs from the years (n-1) to (n+3), and last, industry--the federal government goes as far as financing 100 percent of projects of high risk and of long term. The author attaches great importance to program evaluation at the federal level, which is the principal task of the Ministry of Research and Technology (BMFT). The fact that the author may have a hand in it is perhaps the explanation but in any event it does seem obvious

that the Germans to justify the commitment of public funds, set store by the publication, every 4 years, of a report on research and development (Bundesforschungsberig), publication of which is planned in 1979, not to mention an analogous biennial statistical overview in NSF SCIENCE INDICATORS (Faktenberig 1977).

Lengthy questionnaires are sent with the documents to the scientific, industrial, and political circles of the country and exploited with a view toward better understanding of the needs, and at least to improve the presentation.

The community circles feel that they are directly concerned with these methods of choosing programs and distributing projects, as well as justifying the allocation of funds. They would like to see the organizations and European consulting groups, who are to participate in planning, control and evaluation, defined.[1]

The graphs presented (4, p 6-14 and 6-15) are of extraordinary complexity, not to mention the necessary balance of capabilities of experts and their nationalities within each committee. A concrete example is presented with the [radiation protection] programs.[8]

Evaluation of Laboratories and of Results

The European [Economic] Community is but lightly involved, obliquely by the Joint Research Center which comprises four establishments with total staff of 2,340, of whom 492 hold academic degrees in science.[5]

In any case we are indebted to K. Eichner[2] for an original approach to evaluation of basic research, considered as the result of laboratory activity. Although the "input" (cost of the research: personnel, equipment, and so forth) does not pose too many problems, it is difficult to measure the "output" for which economic parameters are rarely available.

First of all there are the well known objective parameters:

patent statistics (h 20);
inventory of discoveries and innovations;
indices of publications and citations (h 18); and
benefits derived from discoveries.

We shall return to some of those points later on, but the originality of the approach is the addition of criteria such as:

has an existing theory been refuted, confirmed or simplified? (h1, h2, h3);

have the basic elements of a theory been reconciled? (h4);

have gaps been identified? (h5)

have new basic elements of a theory been developed? (h 6); and

is the theory developed more advantageous (h 7) or more complete? (h8)

There may also be added comparison of the results achieved with those which had been intended for the project, and even a connotation of political, economic, or social nature. A failure in one of those sectors may be compensated by success in another.

Another concept is to observe that certain criteria assume greater importance in the various stages of the evolution of a science: in the initial phase with a number of competing theories h1, h2, h3, h4, h7 and h8 must be favored; in that phase of evolution where there are several established schools of thought and a definite scientific community the factor h5 is important; and last, in the routine phase h6 is of interest.

The author of this presentation briefly summarized here does not neglect to mention the principal difficulties: how to determine to what extent each criterion has been met? How to determine the evolutionary phase of a science? How to evaluate the various degrees of realization of an objective? It seems salutary to him that the committees responsible for evaluation and control should have no power of decision at all and that such committees should include, to the extent of half their membership, experts from outside the Scientific Community and that members be appointed only for a term of 3 years. It seems important to him that determination of the degree to which certain objectives of an organization have been realized continue to devolve upon the research investigators who work there, even if they must be provided with the assistance of investigators in different disciplines (sociology, psychology, business administration).

As far as applied research is concerned[3] the members of the European Communities have less precise notions: they advise avoiding evaluation formulas which are too general because they are inoperative and unusable or too specific because they may impede research processes.

The NSF[6] does not seem to add anything else of interest: "The only ones actually able to judge basic research are the investigators themselves, and particularly the best among them, but the time which eminent minds have available is one of our most valuable trump cards: how much time are we prepared to take away from basic research in order to undertake an evaluation...? Too often the data necessary for a satisfactory evaluation are quite simply lost while the research project is being carried out."

The other contributions are happily more pragmatic. On the whole, evaluation of results can be based upon three criteria[5, 13]:

indicators related to increase of knowledge;
indicators related to the extent of cooperation with the outside world; and
economic evaluation criteria.

In the first category are publications (reports, published articles and conference papers, taking into account the notice which publications or congresses receive, and citations in the International Citation Index). Even though it is true that quality can vary, it is not ridiculous to contend that over prolonged periods the average quality tends to remain constant. In this vein the "output" of six Irish research organizations was measured[13]: it was established at an average value of between 0.5 and 0.7 document per scientist per year (figured over 5 years). The author points out--this was established at the CNRS quite independently--that the Economic and Social Research Institute (ESRI) attained a value of 0.95 because that institute is "more science than technology oriented"[13, p 12]. Last, the trend on the whole is said to be rising. However, "one may publish much but do little that is new."

From a study of productivity in university chemistry departments in the United Kingdom it is found, for example, that "the importance of work at the industrial level in no way significantly correlated with the quantitative flow of documents nor recognition by peers."[13] The most evidently used method was to inventory patents and licenses and also original training and educational activities.[5] As a matter of fact this is inadequate: "research institutes and universities have a low yield."[13]

A method cited in (13) has been proposed for determining the source of new technologies. It was tried experimentally in Ireland. It consists of questioning the responsible officials of every industrial firm--in Ireland firms with fewer than 50 employees were excluded and more than 100 exploitable documents obtained--in the following:

to specify the most significant changes related to products and processes which took place within their firms in the last 7 years and to assess the source of each change (another Irish or foreign firm, research institute, university, documentation, exposition, and so forth); and

to define the nature of assistance provided from the outside in order to place these innovations into operation (another firm, supplier, consultant, research institute, and so forth).

Preliminary results reveal that in Ireland the research institutes and universities were the source of 1.4 percent of new ideas and of 2.6 percent of their operational installations.

A cross-analysis comparing results with stated intentions of public laboratories for the dairy industry was performed in an attempt to indentify the motivation force of the research: which research work was requested by the industry and which undertaken upon the initiative of a research investigator. Unfortunately, the author does not give the results of his investigations.

The second group of indicators is related to exchanges with the outside. It is obviously appropriate to take account of participation in research programs by different organizations, specially international, of the number and frequency of visits by foreign experts, and of eventual recognition by the industrial sector. The concept of external contract makes more or less sense, depending upon how the evaluation of objectives and programs is organized. If in fact the latter are scheduled to proceed with commitment of virtually all personnel there is hardly any flexibility to assign personnel to work performed upon request. We observe that in the aggregate, in the German universities 20 percent of research and development is financed by contract (that figure is in turn subdivided into 13 percent subsidized by the DFG, 4 percent by the BMFT (Ministry of Research) and only 3 percent by other parties.[15]

Last, an evaluation in accordance with economic criteria is very valuable because an organization or society is obviously not prepared to finance all research activities, and its management or its public opinion which are the source of the resources insist on having the benefits resulting from the initial choices made evident[3, 10]. Several observations must be made before presenting several methods. Even though it has been verified that the contribution of research and development work to economic growth is great it nevertheless varies, depending upon the type of industry and the source of financing (public or industrial) and an important analytical supplement is necessary.

On the other hand, the closer one approaches basic research or subjects which are wholly research, the more difficult this evaluation. Last, the success of a policy of innovation, making it possible to see benefits flow from it, requires time. According to (12), 25 percent of innovations account for 90 percent of the sales total of all the innovations in the portfolio of the Community Research Center, and the gaps do not all originate in the laboratory. The inventions which reach the stage of commercial exploitation represent a small percent (12, p 16) (13) not to mention that research results often appear in unpatentable forms,[11] and that they may arise during a phase where there is a lack of confidence in the enterprise responsible for development.[13]

The degree of success will also depend upon the innovation strategy adopted: the industrial concept put into operation in the industry leads to successful new products in greater proportion whereas it is the concept of an institute put into operation in the industry which is the origin of procedure replacement.[13] "Therefore, the best solution would be to let the industry take the initiative to the extent that product innovation is involved; in contrast, research personnel are better situated to grasp beneficial process innovations." (13, p 23)

Let us return to the primary objective(?)[16]: to effectuate a cost/project analysis. Several reports attempt to provide a solution.[13, 7, 9]

In the case where a process or product makes savings possible (increased production, for example) this is the indicator which can be used and related to the annual cost of the effort.[13]

In the opinion of (7) it is appropriate to incorporate the costs over the life of the product, [apportioning] them in accordance with whether they are purely national or whether they enter into balance of payments.

Such methods are hardly applicable to more basic research. That is why the ECNR [European Council for Nuclear Research] views the problem differently. This research center considers that, by its requirements and its counsel in the supply of equipment, it has considerably helped the manufacturer who can then incorporate his "know how" in the production of more conventional equipment: cited are magnetic circuit computers of subsequent usefulness in electric motors, computer controlled drafting tables, electronic equipment, cryogenics, and so forth. The advantages which benefit industry are of two kinds: increased business volume as the result of a contract with the ECNR, which is an excellent reference, and perfection of new products and processes at ECNR expense.

To quantify the impact the existence of the ECNR thus has upon industry, 134 suppliers were questioned between 1973 and 1975 and the "utility/sales" coefficient by major sectors, that is, the ratio between, on the one hand, the benefits received by the industrial contractors from the products selected by the ECNR and sold in the economic sector, and on the other hand, the total of its sales to the ECNR. That ratio is 17.3 in data processing, 1.7 in cryogenics (which has no industrial outlets), 4.8 in electronics, in the vicinity of 1.5 for electrical equipment, 31.4 in mechanical precision products, and so forth). By this method it can be proved that the cost of the ECNR between 1953 [as published] and 1973 is amply covered by the short term indirect "fall out," not to mention the unquestionable addition of scientific value.

Conclusions

This seminar posed more questions than it answered. The universal evaluation screen will not be here tomorrow! Independent of methods remains the problem of "the evaluators." The greater the extent to which the interests at stake become important, the more the political man will be tempted to take them in charge with his own value scale of success or failure. The justification for the social sciences is full swing and the change in public opinion regarding the exact sciences and the incessantly increasing costs of research are impelling him to it. Scientists must recognize that control over research is in their own interest. But it is important to distinguish between evaluation of a research project or program and that of people, and moreover, it must be clearly understood that a result may be a successful one within one system and at the same time unexploitable within another. Last, it is necessary to know how to evaluate the evaluators! In any event the results of evaluation must be

discussed with the scientists responsible for implementation, provided that the stumbling blocks of permanent evaluators or those too closely related to the projects discussed are avoided.[15, 3]

A codified evaluation should help each participant: director, evaluator, research investigator, and so forth. Unfortunately, experience shows that specific criteria for each domain must be developed. There does not now exist any scientifically based evaluation methodology. In the United States quantitative methods were developed but a distinct about-face by the public authorities is moving toward a more qualitative system (Peer Review). In industry the highly formalized evaluation methods remain, improved, for more basic work, but giving them the absolute character they previously had is now avoided.[4] But, on the other side, care must be taken that evaluation does not remain an art, for the art and concrete effects must both be observed without, for all that, impeding the development of original ideas.

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11706
CSO: 3102

NEW IGNITION SYSTEM FOR NUCLEAR FUSION OUTLINED

Duesseldorf BRENNSTOFF-WAERME-KRAFT in German Jul 79 p 270

/Text/ In the meantime the prospects have considerably improved for creating a burning fusion plasma, which is an essential presupposition for obtaining energy from nuclear fusion. The Max Planck Institute for Plasma Physics (IPP) has decided to begin the planning of an experiment in which thermonuclear heating can be investigated for the first time. This experiment will thus supplement the worldwide fusion program in an important point.

The new project is called ZEPHYR (Ignition Experiment for Physics in the Reactor). It is a high-field tokamak which will make it possible to achieve the objective mentioned above in a particularly compact geometry.

The planned system is supposed to reach temperatures and densities for the plasma, which will lead to "ignition". By this is understood a condition, in which the plasma heating, caused by the α particles generated in the fusion of the deuterium and tritium, is sufficient to compensate the energy losses of the plasma. No outside heating is then any longer needed to maintain the plasma temperature.

So as to be able to fulfill the relatively high demands for personnel and means, the Institute has decided to restrict or terminate a number of other activities. Work on the projects Belt-Pinch, INTEREX, Pellet-Plasma Source, PUSTAREX, and Pulsator will be terminated this year. Work on the projects WEGA in Grenoble will be terminated nex year. The personnel demand for ZEPHYR will gradually comprise the major portion of the IPP. But collaboration on JET will continue to remain an important feature of the Institute program.

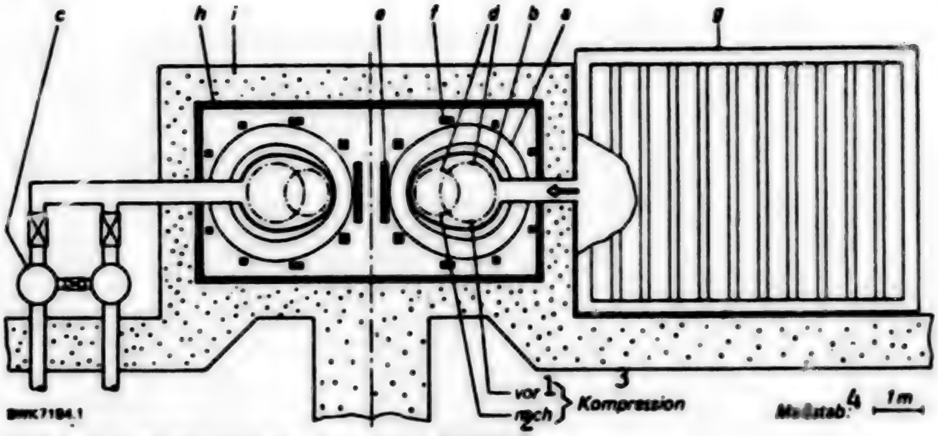


Bild 1: Querschnitt durch das Experiment ZEPHYR

a	Hauptfeldspule	*d*	Plasma	*g*	Neutralstrahl Injektor
b	Vakuumgefäß mit Hitzeschild	*e*	Transformator-Spule	*h*	Kühlbox
c	Vakuumpumpen	*f*	Gleichgewichts-Spulen	*i*	Innere Beton-Abschirmwand

Figure 1: Cross section through the ZEPHYR experiment

a Main field coil
b Vacuum vessel with heat shield
c Vacuum pumps
d Plasma
e Transformer coil
f Equilibrium coils
g Neutron beam injector
h Cooling box
i Inner concrete shielding wall

1. Before
2. After
3. Compression
4. Scale

8348
CSO: 3102

SMALL-SCALE USE OF ALTERNATIVE HEATING TECHNOLOGY DESCRIBED

Hamburg ZEIT MAGAZIN in German 7 Sep 79 pp 7-14, 74

/_ Report by Wolfram Runkel and Manfred Manke_7

/Text_7 The chimney sweep shook his head energetically: "Well now, that can't be!" But Mrs. Angela Becker from Birenbach at Goeppingen insisted, "No, there's no chimney in this house." She invited the chimney sweep to inspect the house. After searching in vain, the man turned pale. He saw a dark future: "You're robbing us of our jobs!"

More important than liberation from the black fellow is Mrs. Becker's independence from the black gold: from oil and coal. Her house is heated only with environmental energy, with wind, air, and sun, reinforced by a heat pump. Heated? The builder and inventor of this house, Construction Engineer Hans Weiss, says, "My houses have no heating. The clean Weiss energy takes care of thermal comfort."

In fact, the Weiss heating system is the most original, practical, energy-saving, environmentally compatible, and cheapest model of all the 10,000 to 20,000 currently operating alternative energy systems in Germany - be they solar collectors, windmills, or biogas heaters.

It functions with amazing simplicity: The outside walls and the foundation soak up reinforceable heat from the environment. The Becker family has comfortably and cheaply already survived two winters, among them the hard one just passed.

Inventor Hans Weiss is a typical tinkerer and creator from Swabia. He takes his leave from a group of high-wattage gentlemen from the electrical business, greets a six-man group of visitors from industry, in order to sign a contract for 40 houses with "Weiss-energy". In the meantime, he explains his principle to us.

"I simply forgot everything that I knew about conventional building construction and heating, and then I started to think." Then he came up with the following insights: "Environmental energy is constantly working

on the walls of our houses. Everyday, the walls are heated from outside, and are cooled by night. Energy is constantly going in and out, in and out. Couldn't I use this energy?" Or: "The heat which again exits to the outside from these residential buildings, can't I recover it in the exterior wall before it finally evaporates?"

In particular, he had to free himself from the narrow-minded, typical human egocentric way of thinking, that everything below zero degrees, and for some people even below 20 degrees, is already cold. "In reality, minus 15 degrees is still warm - in comparison to minus 18 degrees."

His energy system is built on this difference of three degrees - and on well-insulated exterior walls, and on a quite standard heat pump, which functions just like a refrigerator: A refrigerator extracts heat from the foods in its interior, and delivers this heat to the kitchen through its rear wall. As a side effect, it also heats the kitchen a little. The heat pump extracts heat from the outside air and reconducts it into the interior of the building.

The outside walls consist of two especially thick concrete walls, between which there is a 10 centimeter thick styrofoam layer. Helical plastic tubes are cast into the outside concrete layer: The heating and transport way. The Weiss juice flows through these veins. This is water provided with antifreeze and anti-friction agents. The water is heated to the outside temperature. It arrives at the heat pump, which extracts three degrees of heat from the fluid. The cooled water now again flows into the tubes within the exterior wall, and is again heated in its circulation, returns again to the heat pump, and again and again fetches heat from outside to inside.

The heat pump compresses the permanently extracted three degrees of heat to temperatures up to 45 degrees. It delivers this heat to a second water loop, which again flows through plastic tubes in the interior walls and floors. This circulation "brings thermal comfort into the house".

The joke is that this system functions exactly the same when the external temperature is minus 15 degrees. In this case too, the heat pump gets its three degrees; now it cools the fluid to minus 18 degrees; during its circulation, the fluid is automatically again heated to the "warm" outside temperature of minus 15 degrees (heat always becomes cold). Of course: the colder the outside temperature, the more power will the heat pump require, the more current it will use in order to tap the three degrees.

But even in the previous cold winter, in which temperatures fell to minus 15 degrees with extraordinary frequency, the heat pump in the Becker home used up only 7,000 kilowatt hours, about 700 marks for electrical power. A conventional oil heating system in this house would have consumed about

5,000 liters oil, costing about 2500 marks. Weiss calculates as follows: "Distributed over the year, I obtain about four kilowatt hours heating energy for one kilowatt hour electrical energy."

Furthermore, Weiss utilizes not only the outside air temperature. His houses are dark brown, so that sunlight is not reflected so strongly; the heat stays in the wall. In order to use the wind and the "heat friction" in a favorable manner, the Weiss houses have very rough, relief-like outside walls, which doubles the friction surface: "My outside walls are always warmer than the air."

Incidentally, the internal heat, which wants to escape to the outside through the well-insulated walls, is immediately again intercepted by the outside walls, as soon as it has fought its difficult way through the styrofoam layer. Energy recycling. As paradoxical as it sounds, the Weiss house walls are heat storage units and heat collectors.

"At first, our neighbors thought we were crazy," says Angela Becker. She's also happy about the fact that she has less cleaning to do than in the "oil houses". "But last winter, when they found out that we use the air to heat to 24 degrees, they became a little cautious. Since the houses here are very close to one another in the Swabian style, our walls eagerly soak up the air flowing out from the poorly insulated walls of our neighbors. The neighbors think we are stealing their heat. Now they are insulating their house." Swabian troubles.

During our visit, Weiss sold to the North Rhine Westphalian Construction Company Architecta the right to build 40 new houses after the Weiss system. Will these houses be expensive? The Architecta Manager, L. Grosse-Frintrop, has already figured it all out: "The houses with oil heating would cost 310,000 marks. With the Weiss system, they will cost 10,000 marks more. The tubing is even cheaper than the conventional oil heat piping."

In the meantime, Weiss has given a lecture about his model to Austrian energy scientists. The Austrian Government will soon build entire building complexes in accord with his principle.

And the German Government, which is supposed to be so worried about alternative energy? Weiss shrugs: "They can kiss my ass. I wrote to Hauff, and asked for research aid, but first they didn't catch on, and then they said it was old hat. They don't give money to private people; they spend all their money on atomic energy."

In fact, all researchers and tinkerers whom we visited have experienced frustrating aggravation with the agencies in Bonn and with local agencies. Support is rigorously denied to individuals. The Government makes

available a ridiculously small portion (about one percent) of the total energy research program for pursuing environmental energy. All of this goes to large corporations, such as Stiebel-Eltron or MBB. In part, these corporations use these funds to develop simple, quite ineffective heat pumps.

The entrepreneur Rolf Hermann also had bad experience with the agencies. He owns a small tool factory in the neighborhood of Stuttgart (40 employees). Shortly after the first oil crisis, in 1973, he wanted to build a house with alternative energy. First, the architect went on strike. Like about 90 percent of his colleagues, he was not prepared to consider alternative heating even in theory. Hermann wanted to obtain the heat for his 420(!) square meter alternative house from the ground. At a depth of 1.50 meters, the ground temperature never falls below +10 degrees, even in the coldest winter. Consequently, the garden appears as an ideal heat source. Like Hans Weiss in his house walls, Hermann wanted to extract heat from the ground of his garden, by means of a branched pipeline system and an appropriately cold fluid. This heat was to be transported to the heat pump. As usual, the heat pump pumps up temperatures and operates a heating system.

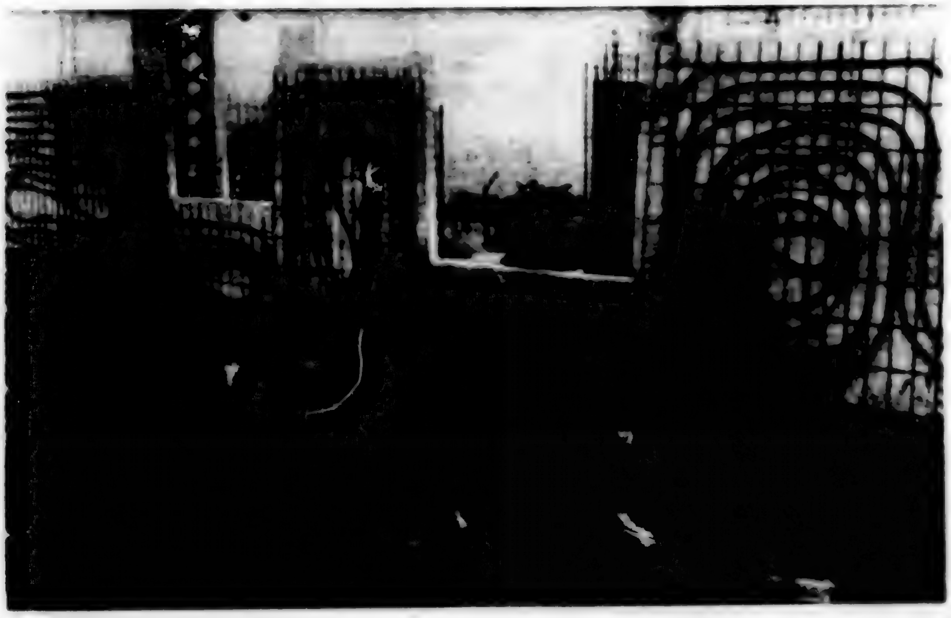
Hermann can get 30,000 heat units from his 800 square meter garden. This is adequate for the annual demand of his house only with nearly hermetic insulation. His house therefore has styrofoam outside walls, and the intermediate spaces of his triple windows can be closed hydraulically by pushbutton.

But he wanted a second heat source for safety. He rejects solar collectors as ineffective: "The sun shines only when you don't need it, in the summer."

He hit on the idea of using the environmental energy from the air, wind, and rain, by means of special pipelines and absorbers under a copper roof. The principle is the same as Hans Weiss's in his walls. At a large solar fair in 1977 in Munic' he discussed his project with representatives of the electrical indust ich is so heavily supported by the Government. But he was only ridic A representative from BBC Mannheim "laughed at me. Monovalent - t. will never work; you're crazy." Only a small Munich entrepreneur, Volker Naaf, thought it might work.

And it did work. For two years, Hermann has been heating with environmental energy. "Depending on the weather, I operate the roof or I operate the ground."

Does it not feel strange to obtain one's heat from the environment? Sober Swabian merchant that he is, certainly no opponent of atomic energy or ideological energy saver, but only a simple saver, he says: "I'm happy not to need xpensive and dirty oil." He estimates that he has paid



Spiral Tubes in the Walls

Inventor Weiss cast spiral plastic tubes into the exterior walls of his house. A fluid circulates within these tubes. The fluid heats to the outside temperature, flows through a heat pump, where three degrees of heat are removed from it, and is then again reheated. The three degrees of heat are tapped constantly, and are compressed by the heat pump to usable heating temperatures

70,000 marks more for his system than he would have spent for a conventional heating system. But he would have needed at least 10,000 liters oil per year for his 420 square meter house: He is already saving 3,000 marks (the heat pump last winter cost him 650 marks for electrical power). If oil prices remain the same, his amortization time will be 13 to 14 years."

When Hermann approached the agencies for research means, he was written off: "We have our test house in Aachen. We'll make measurements there for five years, then we will wait two years, and then we'll have another look.

By that time, much oil will flow down the pipelines. The uninhabited solar test house at Aachen, which has been quoted so many times, and which is so heavily supported by the Federal Government, (see ZEIT Magazine No. 23/77), in which human body heat is even simulated by burning incandescent lamps, is used for quite different purposes by the generously financed Philips Corporation. A Philips man said to a Hamburg heating engineer: "We are not interested at all in all of this solar technology. For us, this house provides a cost-free opportunity to test new computers."

Erhard Eppler improved his house in the Black Forest by means of solar collectors. We asked him too concerning the befogged view of the Bonn agencies in researching alternative energy. The Ex-minister and energy expert expressed the following opinion: "I have to protect (the Research Minister) Hauff. In any case, he is not quite so one-sidedly fixed on atomic energy and large corporations as his predecessors." But he too could not name a single case of official support of private research activity.

Eppler himself has not had good experience with his collectors. "I paid for my ignorance." Solar collectors do have the advantage that they directly convert heat from the sun into hot water circulation. They do not use the electricity-consuming heat pumps, which Eppler rejects in principle. But solar heat is scarcely available precisely when it is needed. This saver of electricity, who even heats his sauna with wood that he himself has chopped, only has half of his hot water supply secured by his 10,000-mark solar collectors. He has an annual saving of about 150 marks for electrical costs.

Solar energy is abundantly available in the summer. In order to save at least part of this for the winter, Eppler has now bunkered a gigantic 20,000-liter water tank in his garden. There he stores the summer solar energy (in the form of heated water). But now he still needs a heat pump for heating up this water. And the 20,000 liters are adequate only for one sunless winter month.

Eckhard Krueger proved that monovalent heating, that is without additional oil or coal supplies, with solar collectors alone, is possible even in Germany and even in Hamburg. His main occupation is to be consulting engineer for heat, air conditioning, and ventilation engineering. Because of his own research drive, and in order "to have the edge in technical know-how in the race with the competition", he has erected a private solar house: With 36 high-grade collectors on the roof, a "ground heat exchanger" like Rolf Hermann in the garden, and a 16,000-liter hot water tank, like Eppler, next to this.

During the summer, the collected solar heat is partly pumped into the garden, whereby the entire ground is heated to at least 20 degrees. In

part, the heat is pumped into the gigantic storage unit, where the water is heated up to 90 degrees as an iron reserve. According to electronic system, a computer decides during the winter, at any time and depending on weather conditions, whether the floor heating should get its heat directly from the collectors (if the sun is shining) or from the hot ground, or, if necessary, from the reserve tank. Conversely, in the summer the computer decides, according to priorities, whether the solar heat should be used directly, or should be stored in the tank or in the garden.

The Krueger solar house is a superperfect, double secured system, equipped with expensive research instruments, that were co-financed by the Hamburg Electrical Works (HEW). It cost a total of 170,000 marks. "I would have to be 150 years old before I could amortize this," says Krueger. In the meantime, he has become somewhat sobered. Suddenly stamped as a solar specialist, he has lost instead of gained conventional heating consultation contracts. The HEW is sending him curious visitors all week long, from common market commissioners and representatives of green lists to time-consuming guided tours in the house. The agencies are denying him the legally promised support for energy-saving measures (with enterprises from 12,000 marks on, either 3,000 mark cash or 10 percent of investment costs annually deductible from taxes). They merely remark that his system does not fall under this favoring clause.

Most friends of the sun, of course, have already earlier been aggravated by the agencies. Especially in Bavaria, the CSU Agencies are flirting with atomic energy, and solar collectors are considered as left-wing visionaries, if not quite terrorists. The solar roof engineer Josef Probs from Weiden in the Oberpfalz reports that the Weiden building agencies decide applications for installing energy roofs by immediately announcing that the application can in no case be considered before six months. In other south German areas, solar collectors are simply prohibited as ugly.

Nevertheless, the German Society for Solar Energy estimates the number of wind and solar heat users, in the broad sense, at 10,000 to 20,000. Most of these, of course, use solar energy as a supplement to the oil supply. Owners of old buildings are primarily dependent on such "bivalent" heating, since they do not have floor heating but conventional radiators.

The most favorable "bivalent" heater is the so-called air-water-heat exchanger. This is a box-shaped unit, which pumps in outside air in the garden, withdraws a few degrees of heat, and pumps this heat up to heat the hot water.

However, this pump works economically only at temperatures above zero degrees, often above three degrees. At lower temperatures, that is at 20 percent of the heating days in Central Europe, the device automatically

switches to oil heating. With an original oil demand of 5,000 liters (2500 marks), the heat pump would, for example, replace 4,000 liters of oil and use up about 5,000 kilowatt hours (about 500 marks). The heating costs would therefore total only about 1,000 instead of 2,500 marks. Since such a system costs between 12,000 and 16,000 marks, it is amortized in seven to eight years.

The Hamburg heating engineer and business man Ernst Sager last year paid 16,000 marks to acquire a commercial air-heatpump for his yard. During the unusually cold winter just passed, he had to heat with oil from the middle of December to the middle of March, for about 820 hours, at temperatures below three degrees. He consumed 1870 liters oil, which would have cost 1435 marks at present prices. During the time from March to December, the heat pump ran 1200 hours and consumed 6403 kilowatt hours for exactly 768.36 marks.

Sager's heating costs for the year were therefore 2203.36 marks; had he heated only with oil, he would have consumed 7,000 liters for an equivalent 3500 marks. Saving: 1396 marks.

Biogas is an especially effective type of environmental energy. At the present time, this is obtained only in agriculture, from cow dung. In China, of course, there already exist half a million small systems, which even convert human feces into energy. Again in Swabia, we visited the former FDP Parliament Official Fritz Weber ("I worked with Ertl in the same room"). Already in the fifties, he built a biogas system, but he used it only to obtain manure, because oil prices were so cheap. But now he is starting it up again with government support.

The offal of 56 cows is conducted directly from the cow barn, together with the liquid manure, into the large fouling silos, where it is combined with straw. The gas develops during the decay process. Weber uses this gas for heating. He obtains about 50 to 60 cubic meters gas daily from his cows, corresponding to 30 to 40 liters oil.

With this total recycling ("the manure burns"), he obtains not only energy but also high-grade manure valued at 6,000 marks annually. He would prefer to convert the gas into electricity by means of a generator, and to sell the electricity to the electric power plants. "But they don't cooperate, after they have acquired a monopoly by purchasing smaller energy sources and forcing them to shut down."

Brother Bierwirt of the Benediktbeuern Monastery can also tell a tale about this. Since 1955, he has been taking care of the monastary Bihu (bio-humus) system. This system uses the manure of 180 cattle to obtain a daily average of 200 cubic meters gas. This gas is partly used for cooking in the monastery kitchen, for 2,000 brothers, and is partly

used to obtain electricity. The Isar-Ampere Electrical Works tried to choke off this gas system: The Electrical Works promised to continue supplying the monastery with electricity only under the condition that the biogas system be used exclusively as an emergency unit in case of power failure. Only an intervention by the "Association for Natural and Environmental Protection" preserved the monastery from the consequences of this extortion. The Electrical Works capitulated.

The wind is one of the most fascinating natural energies. Centuries ago, wind made possible the discovery of remote continents and even today affords one of the most popular types of sport.

But as on water, on land the truism holds: Everything stops during doldrums. The wind is unreliable. For this reason, windmills with generators can only partly be used as energy sources. In Schleswig-Holstein, in the neighborhood of Trittau, the bank employee Zander built himself a windmill with a five meter wing span five years ago. At wind intensity three, a weak wind, which barely moves leaves and twigs, this system already provides six kilowatts. Over the year, he told us, he gains 12,000 kilowatt hours, which he uses for heating: "On the average, I save 100 marks per month." When there is no wind, he heats with coal, 70 to 80 hundred weight per year.

"Nevertheless", says a spokesman of the Hamburg Electrical Works, "wind as an energy source lays a big egg. The windmills are ugly, loud, and noisy. During doldrums, they go bust, and during severe storms the wind user trembles for his mill. These things have often been torn from their foundations."

In the East, the wind obviously blows differently. A farmer in the GDR recently equipped his tractor with wind wings: "At wind intensity two, it runs, at wind intensity four it pulls like four horses," announces the inventor, "and when the wind is less, we don't work."

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FEDERAL REPUBLIC OF GERMANY

PROBLEMS, CHARACTERISTICS OF TURBOCHARGED ENGINES STUDIED

Wuerzburg AUTOMOBIL-INDUSTRIE in German No 2, Jun 79 pp 19-24

[Article by Hermann Hiereth]

[Text] The studies described here were performed to investigate a number of issues: Supercharging the Otto engine by means of an exhaust gas turbocharger strongly increases the power density of such a drive. Can this produce the necessary or desirable running performance more economically and with less pollution than the conventional naturally aspirated engine? Which problems must be solved in designing the engine, in matching the exhaust gas turbocharger, and in regulating the overall system? How does the supercharged Otto engine compare to a naturally aspirated engine of the same power, as regards its running characteristics in a passenger car?

Today, the predominant power plant for passenger cars is the Otto engine, because it can very well fulfill the most important requirements for such a power plant, namely a high power density, i.e. small space and low weight. Furthermore it runs quietly, is reliable, and is inexpensive to manufacture.

In the future, reduced emission of pollutants and at the same time improved efficiency will certainly be required. The reasons for this are the increase of environmental pollution by exhaust gases on the one hand, and the more and more conspicuous shortage of raw materials on the other hand. These requirements reduce the advantage of the Otto engine. Reduced emission of pollutants requires controlled combustion. The most important combustion parameters, such as the shape of the combustion chamber, the ignition timing, the composition of the mixture, etc. will have to be chosen, not from power considerations, but from emission considerations.

The requirement for less emission of pollutants consequently quite generally reduces the power yield and therefore increases the fuel consumption of such an engine. Both the indicated efficiency as well as the mechanical efficiency decline because the useful power is reduced.

However, the mechanical efficiency of an engine can be considerably improved by increasing the overall load factor of the drive. This is achieved to the greatest possible extent by increasing the charge in the working cylinders, by compressing the mixture, in other words by supercharging. Supercharging an engine can therefore achieve both reduced emission of pollutants and improved efficiency. This holds especially for application in vehicles, where the engines are generally run at a lower load, in a range where the useful power of an engine is small compared to its drive-specific loss power. Fuel consumption in this range therefore becomes quite high.

For example, if the engine power required for a particular vehicle design is provided in one case with a naturally aspirated auto engine and in another case with a supercharged Otto engine, the supercharged unit can use a smaller basic drive with a lesser mechanical loss power. Because of the better useful/loss power ratio, the partial load fuel consumption must be better than with a naturally aspirated engine of the same power. However, this presupposes that both engines have the same combustion characteristic or, more precisely, the same indicated efficiency at this partial load point.

But now here begin the problems in supercharging the Otto engine. With the Otto engine, the combustion characteristic and consequently the achievable indicated efficiency is limited by the fact that uncontrolled combustion by spontaneous ignition of the mixture, so-called knocking, may not occur at any operating point of the engine. In order to estimate whether the supercharged Otto engine can achieve the same process efficiencies as the naturally aspirated engine, at least at comparable partial load points, it is necessary to investigate the knocking conditions of the supercharged engine.

1. The Knocking Limit of the Supercharged Otto Engine

According to present opinion, knocking combustion in the Otto engine is caused as follows: The spark plug starts ignition in the normal manner. The advancing combustion causes the pressure to rise, and the unburned mixture before the flame front is therefore compressed. The resulting temperature rise causes spontaneous ignition. This mixture residue then burns very quickly and therefore causes pressure oscillations in the combustion chamber. At the same time, extreme heat transfer occurs in the detonation waves. These factors lead to the mechanical and thermal destruction of the engine. Knocking combustion must therefore be avoided under all circumstances.

The following parameters affecting the knocking process will be discussed:

Condition of the Mixture

The condition of the mixture is characterized by the air-fuel ratio λ, the anti-knock properties of the fuel, in other words the octane number (ROZ), and the temperature of the charging air T_L.

Figure 1 shows that the anti-knock characteristic of the fuel, as expected, strongly affects the superchargeability. The latter is here represented by the achievable charging pressure P_L at the knocking limit. It can also be seen that - as a consequence of internal cooling - a richer mixture can achieve a higher charging pressure than a lean mixture. The large effect of the temperature of the charging air should be especially emphasized.

Reducing this temperature by cooling the compressed air before it enters the cylinder is therefore very effective with the supercharged Otto engine. This requirement for cooling the charging air becomes even more stringent when one also considers the parameter:

Ignition Timing

Figure 2 shows that the ignition timing can be favorably advanced only when the entry temperatures of the mixture is low, corresponding to low charging pressure values P_L.

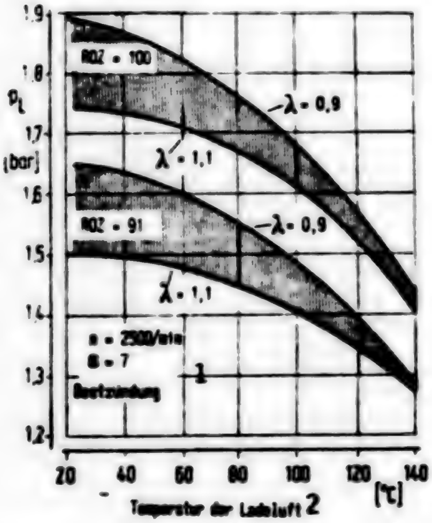


Figure 1: Charging pressure at the knocking limit in the case of optimum ignition, in dependence on the temperature of the charging air, for various air ratios and fuel qualities.

1. Optimum ignition
2. Temperature of the charging air

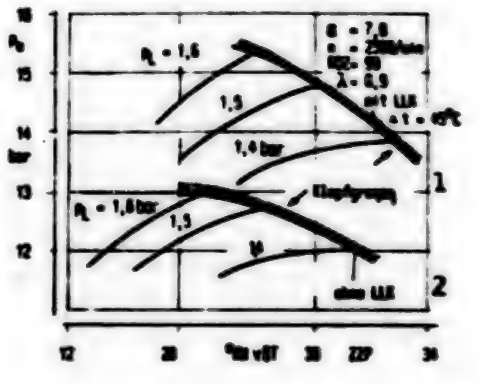


Figure 2: Average pressure in dependence on ignition timing and charging air cooling.

1. Knocking limit
2. Without charging air cooling

But the most important information obtained from this figure is the fact that the supercharged Otto engine generally reaches its knocking limit before its optimum ignition point. Consequently, the supercharged Otto engine cannot have a wide margin between ignition and the knocking limit, which would be desirable for safety reasons. Such a margin would entail considerable losses of power and efficiency in the full load range. This implies that, in this case, the ignition time must be set near the knocking limit, very precisely, and over long operating times. Alternatively, a knocking sensor must be developed, which is capable of regulating the ignition time very close to the knocking limit, depending on fuel quality and engine conditions.

Compression Ratio

The compression ratio ε influences knocking conditions through the final compression pressure and temperature. Lowering the compression ratio consequently should strongly affect the knocking limit with the supercharged auto engine. But this also reduces the efficiency of combustion, especially at partial load. The amount of residual gases in the cylinder rises as ε decreases. This causes the fresh mixture to be heated. Consequently, the improvement of anti-knock properties and consequently the improvement of superchargeability, which would be expected on the basis of thermodynamic changes of state, are achieved only in part.

The influential parameters of mixture, ignition time, and compression are collected together in Figure 3. This figure shows that e.g. a charging pressure of $p_L = 1.5$ bar, with optimum ignition and a rich mixture, without cooling of the charging air, can be realized only by reducing ε to 6. This reduction is unfavorable for fuel consumption. If the charging air is cooled to 60°C, this charging pressure can be used with a compression of $\varepsilon = 8$. For an economical supercharging of the Otto engine, it is therefore very important not only to develop an ignition system meeting the above requirements, but also to develop a low resistance, effective cooling unit for the charging air, As already explained, these features are required for using a high compression ratio and a fuel-saving ignition setting.

If these experimentally determined boundary conditions are used to reduce knocking combustion, the achievable process efficiencies of the supercharged Otto engine can be obtained with sufficient precision by means of a real process calculation. These efficiencies can then be compared with those of a naturally aspirated engine with the same power.

Figure 4 shows the result of such an estimate. More precise data concerning this calculation will be found in the references /1, 2, 3/.

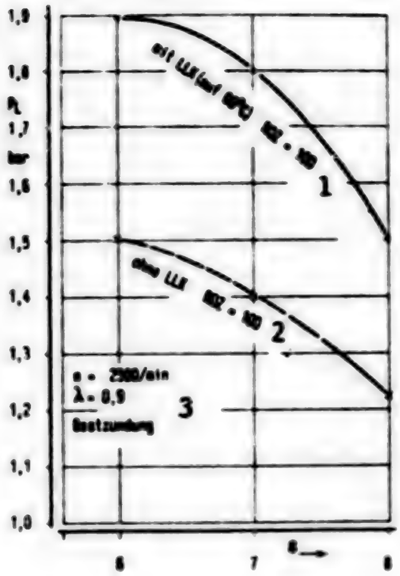


Figure 3: Effect of the compression ratio and charging air temperature on the charging pressure at the knocking limit.

1. with charging air cooling (to 60°C) ROZ = 100
2. without charging air cooling ROZ = 100
3. optimum ignition

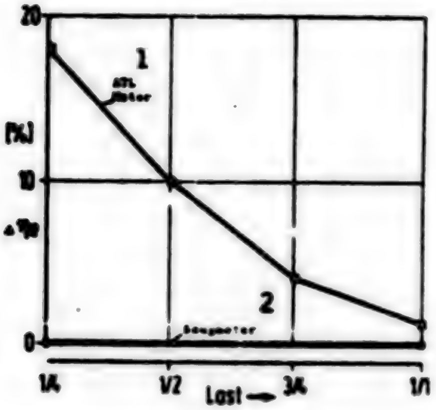


Figure 4: The efficiency advantage of the supercharged Otto engine compared with to a naturally aspirating engine of the same power, in dependence on engine load

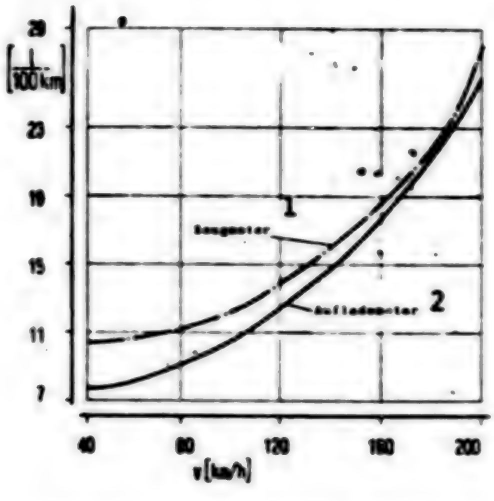
1. Supercharged engine
2. Naturally aspirating engine

The supercharged Otto engine has an efficiency advantage. This advantage can be as much as 15%, with decreasing load.

As Figure 5 shows, these improvements are also realizable with engines in vehicles.

Despite this advantage, supercharging of the Otto engine is being developed only hesitantly. This fact is connected with a series of other problems, in addition to the knocking problem. Up to now, no satisfactory solutions, or only very expensive ones, have been found for these problems.

Several of these problems will be considered in more detail below, particularly to understand them more clearly in comparison to the relatively familiar supercharged diesel engine.



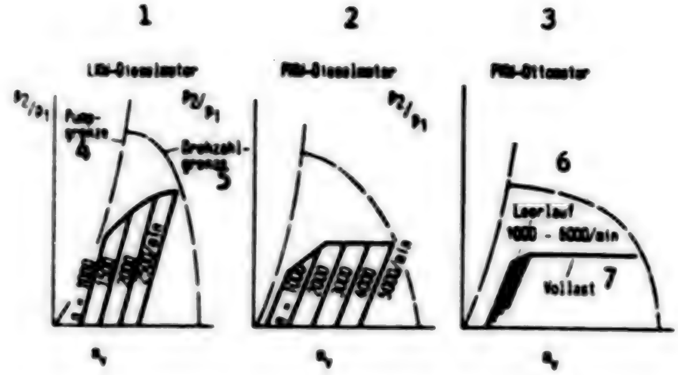


Figure 5: Comparison of fuel consumption of naturally aspirating and supercharged Otto engines of the same power, over their range of running speeds

1. Naturally aspirating engine
2. Supercharged engine

Figure 6: Comparison of the pressure-volume flow characteristic of a truck diesel engine, a passenger car diesel engine, and an Otto engine with exhaust gas turbocharging

1. Truck diesel engine; 2. Passenger car diesel engine; 3. Passenger car Otto engine; 4. Pumping limit; 5. rpm limit; 6. Idling 1000 - 6000 rpm; 7. Full load

Choice of Compressor

As the first problem, we will consider the interaction of compressor and engine, by looking at the volume flow characteristic.

The behavior of the exhaust gas turbocharger is primarily determined by the flow properties of the compressor. These properties are explained by a schematic compression characteristic.

As Figure 6 shows, to the left of the so-called pumping limit, plotted in dashed lines, there is an area in which the compressor runs unstable. Consequently, the compressor may not be operated in this region. The second theoretical limit of the compressor is its maximum rpm. In practice, however, the usable conveyance volume is limited by the compressor efficiency, because efficiencies of approximately 0.6 are scarcely still acceptable at maximum conveyance quantities.

The limiting rpm has therefore been plotted in Figure 6. At the point of maximum throughput, this yields a compressor efficiency η_{is-L} of approximately 0.6.

To evaluate the interaction of the exhaust gas turbocharger and the engine, the characteristics of the engine must also be plotted in this figure: The dependence of the air flow through the engine on the engine speed and charging pressure must be plotted in the compressor characteristic of the exhaust gas turbocharger. But this must be related to the condition of the charger. For unchoked engines with valve crossover, and at constant engine speed, straight lines with a slight slope towards the right will in this case appear in the compressor characteristic, the so-called absorption curves of the engine. The figure shows the simplest case of the unchoked supercharged engine. This is the starting point for deriving the compressor requirements for supercharging the Otto engine.

Engines which - as shown - work unchoked and with a relatively small revolution range between 1000 and 2500 rpm, are currently used mainly in commercial vehicles. The required throughput range of the compressor is narrow and can be covered with good compressor efficiencies. However, for reasons of economy, these engines are usually loaded to capacity, so that the compressor must achieve comparatively high charging pressures, i.e. large pressure ratios p_2/p_1.

The fast-running passenger car diesel engine is increasingly gaining interest for supercharging. As regards the rpm range and the drive design, this leads to the Otto engine. Consequently, the next case shown in Figure 6, middle, is the pressure-volume flow characteristic of a supercharged passenger car diesel engine. The compressor must here already cover a wide throughput range, corresponding to a range from 1000 to 5000 rpm, so that the absorption lines for the high engine speeds already fall within the range of decreasing compressor efficiency. But, with the diesel engine, this is not necessarily a disadvantage. The low compressor efficiency causes high charging air temperatures and consequently also high final compression temperatures. Because the timing delay is shortened, these conditions may be quite desirable.

For reasons of vehicle weight, the power plant has the lightest possible design. In contrast to a truck engine, a supercharged passenger car diesel engine must have its driving load limited through the peak combustion pressure. This is achieved by controlling the charging pressure.

For this reason, the engine operating curve, in the middle section of Figure 6, is horizontal starting from a particular pressure ratio p_2/p_1. But this engine too has a unique association of absorption lines to the respective engine speeds.

Figure 6, right, shows the pressure-volume characteristics of a supercharged Otto engine. The speed range is extended to 1000 to 6000 rpm. It is also necessary to change the type of load control. As is well known, the Otto engine can only be operated within relatively narrow limits of the fuel-air ratio λ. In contrast to the diesel engine, the load control for the Otto engine cannot work by changing the fuel quantity while λ varies considerably over the load. Rather, the quantity of mixture must be changed at constant λ.

Consequently, with the supercharged Otto engine, the absorption lines are no longer associated with engine speeds, in the form characteristic for diesel engines. The altered pressure-volume flow characteristic shall therefore be explained in more detail below.

Beginning at the rated power, that is at the right end of the heavily drawn operating curve of the engine, the following differences can be observed:

The charging pressure is limited just as with the passenger car diesel engine with turbocharger. But here the reason for this is not only that the ignition pressures will rise excessively, damaging the driving mechanism, but also the risk of knocking.

Choking causes the motor load to decrease at higher motor speeds, while the charging pressure ratio p_2/p_1 remains constant. Consequently, only a single absorption line exists in this upper load range, for all load and speed points. The pressure ratios achievable by the compressor drop only at very low air throughputs. This causes the absorption lines to drop off. From this point on, the absorption lines fan out, but there is no association between engine speeds and the absorption line. The differences which do occur are caused by the fact that a somewhat larger air mass is always required for the same average effective pressure, as the motor speed increases. The reason for this is that the friction power in the engine increases. As with the diesel engine, this creates an absorption line characteristic in this range but one that is stacked much closer.

High charging air temperatures must be avoided with the supercharged Otto engine. Otherwise, as already described, the engine will tend to knock, because of the resulting high final compression temperatures. For this reason, since the final compression temperature depends directly on the isotropic efficiency of the compressor, the compressors for supercharged Otto engines must have a high compression efficiency over a very broad range.

But this again underscores the necessity of cooling the charging air in the Otto engine. In addition to the above-mentioned advantages, such as reducing the tendency to knock and favorably influencing the ignition

timing, it also contributes towards reducing the requirements on the compressor as regards the breadth of its characteristic.

One can thus summarize the criteria for selecting a compressor in the case of the supercharged Otto engine:

The compressor must have a large throughput range between the pumping and efficiency limit.

The isotropic compressor efficiency should already be sufficiently high at small pressure ratios and over the entire throughput range.

These requirements are currently already being partly met by compressors with backwards curved blades.

Controls on the Compressor and Turbine Side

Another problem is the response when the load rises from a low partial load. Because its quantity is controlled, only an amount of air adequate to the engine power is available to generate the turbine power, with a supercharged Otto engine. By contrast, with the supercharged diesel engine, an air quantity corresponding to the engine speed always flows through the turbine, independent of load. Consequently, although the exhaust gases have a higher temperature, the speed of the supercharger in the Otto engine always falls more under partial load than is the case with the diesel engine. When the load is increased, the supercharging assembly must first be strongly accelerated. This can sometimes lead to unreasonably long response times when the position of the gas pedal is changed.

Arrangement of the Throttle Valve

The arrangement of the throttle valve is an example for a control on the compressor side, to improve this defect. Its arrangement before or after the compressor considerably affects the choice of compressor on the one hand and the charging speed under partial load, and consequently the response behavior of the entire supercharging assembly, on the other hand. This will be explained in detail below.

For the following considerations, an important fact is that the compressor transports a certain volume, but the motor requires a certain mass of air for a given load. The volume of this mass depends directly on its density. The operating point of the compressor, on the other hand, is determined only by the volume flow and the pressure ratio. Only when the condition of the air before the compressor is specified, can a mass be associated with the transported volume. In one case the choke acts after the compressor, to control the partial load with the supercharged Otto engine (dashed line). As Figure 7 shows, atmospheric

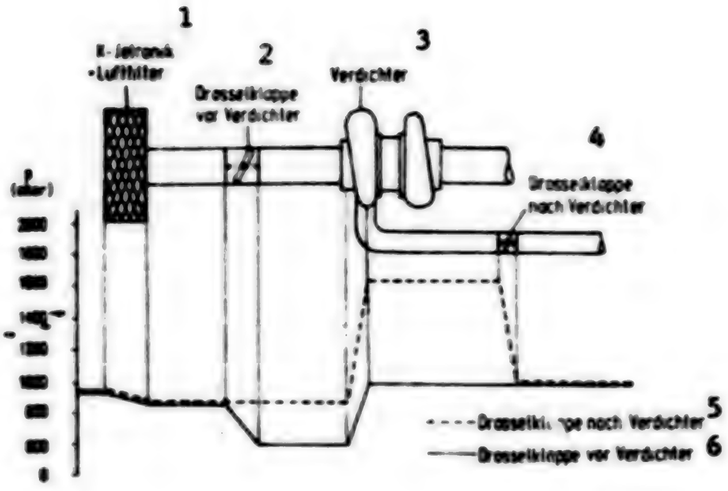


Figure 7: Behavior of the pressure in the air supply system of a supercharged Otto engine, with choking before or after the compressor

1. K-jetronic air filter; 2. Throttle valve before compressor; 3. Compressor; 4. Throttle valve after compressor; 5. Throttle valve after compressor; 6. Throttle valve before compressor

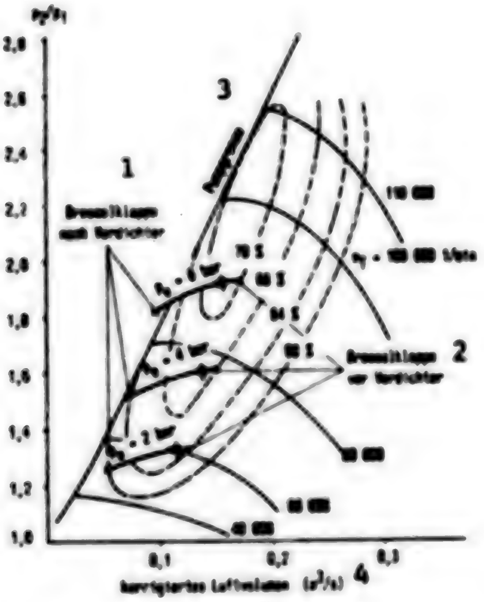


Figure 8: Volume flow points with choke control before or after the compressor

1. Throttle valve after compressor; 2. Throttle valve before compressor; 3. Pumping limit 4. Corrected air volume

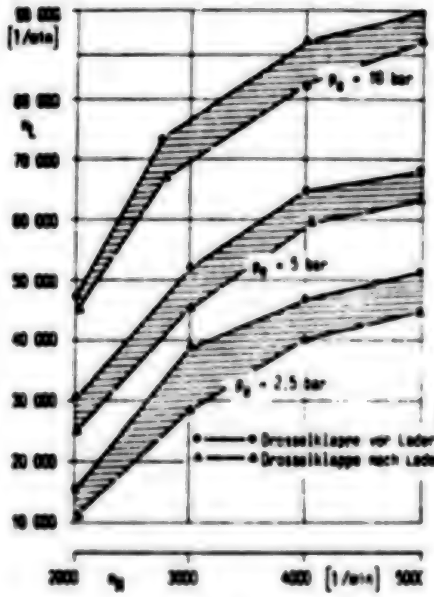


Figure 9: Supercharger speeds when the throttle valve is arranged before or after the compressor, in dependence on load and engine rpm

1. Throttle valve before supercharger; 2. Throttle valve after supercharger

pressure approximately prevails at the compressor intake. The compressor transports air of standard density and compresses this air to a higher pressure. The choke valve chokes this pressure to the desired pressure before the intake valve. At low partial load, this pressure may lie far below atmospheric pressure. This is done with small volume flows, poor efficiencies, and sometimes on the far side of the pump limit. Figure 8 shows this case for average pressures p_e = 2-6 bar (about 15-50% load).

In another case, the choke acts before the compressor. In this case, as Figure 7 shows (solid line), a much lower pressure prevails at the compressor intake than in the first case, and consequently a lower density. This air, at lower pressure and lower density, that is at higher specific volume, is now compressed to the desired pressure before the intake valve.

However, as Figure 8 shows, this occurs at higher volume flows and consequently at better compressor efficiencies and higher compressor speeds, since the turbine power remains the same.

Figure 9 shows that the compressor speed under partial load can be raised up to 10,000 rpm. This considerably improves the response behavior of the turbocharger under increased load. Since the partial load transport does not occur at the pump limit, the requirements imposed on the width of the compressor characteristic are somewhat softened. Because of the smaller pressure differences at the throttle valve, this control scheme also achieves a better control quality and more stable load adjustment. However, it presupposes a type of supercharger which remains oil-tight with respect to the compressor, even when high underpressures prevail in the compressor housing. Even if small amounts of lubricant leak out, they will reduce the knocking limit of the mixture and increase the proportion of unburned hydrocarbons in the exhaust gas.

The arrangement of the throttle valve has been explained in detail. But there exists a whole series of other possibilities to avoid compressor pumping or to improve the response behavior. But these possibilities are generally more costly.

However, if the throttle valve must be arranged after the compressor, e.g. because an oil-tight unit cannot be used, the best results are obtained by an arrangement as shown in Figure 10.

The simple trick here is to activate the blow-off valve not with the pressure after the throttle valve, but with the pressure before the throttle valve. In this way, one avoids a pressure higher than the maximum desired charging pressure without additional blowing of air. Compressor pumping is therefore also reliably prevented.

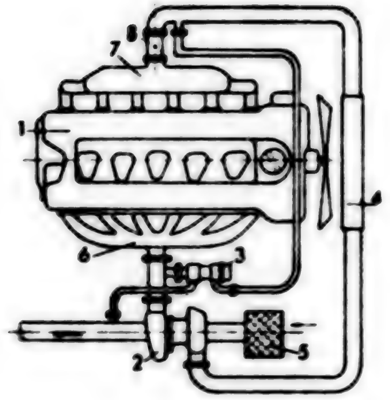


Figure 10: Connection of the charging pressure control when the throttle valve is arranged after the compressor

1. Engine; 2. Exhaust gas turbocharger; 3. Exhaust gas blow-off valve; 4. Charging air cooler; 5. Filter; 6. Exhaust manifold; 7. Intake tube; 8. Throttle valve

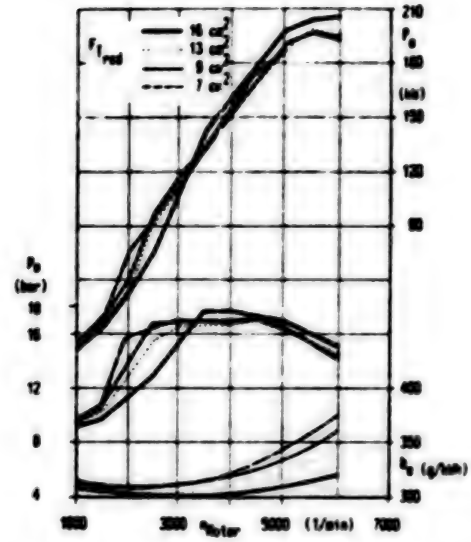


Figure 11: Effect of the turbine housing cross section on the power and torque of a supercharged Otto engine

Finally, we shall treat possible controls on the turbine side: the effect of the size of the turbine housing cross section, and the problems of controlling the charging pressure by blowing off the exhaust gas before the turbine.

Turbine Housing Cross Section

The size of the turbine housing cross section decisively determines the rate at which the exhaust gas flows into the turbine and consequently the achievable charging pressure and engine power. However, as was already indicated in the discussion of the knocking problem, the charging pressure of the supercharged Otto engine must be adjusted very precisely and reproducibly, e.g. by means of a blow-off control. Consequently, the effect of the turbine housing cross section is reduced to the charging pressure and consequently power yield in the lower speed range of the engine. Here, the maximum permissible charging pressure is not yet

attained, and consequently no exhaust gas is blown off. Figure 11 shows the expected circumstances: As the turbine housing cross section decreases, and as the build-up before the turbine therefore increases, the charging pressure begins to be generated at lower and lower engine speeds. For good vehicle operation, the torque must increase at low speeds. Accordingly, the smallest possible turbine housing cross section would have to be chosen. As the figure also shows, fuel consumption also rises thereby, particularly strongly so at higher speeds.

This increased consumption has several reasons.

A first reason is the rigid geometry of the turbine housing. This makes it impossible to affect the turbine through the intake flow speed of the exhaust gas flow from the engine. The resulting consequences as regards the pressures in the exhaust system before the turbine on the one hand, and the turbine power on the other hand, will be discussed below.

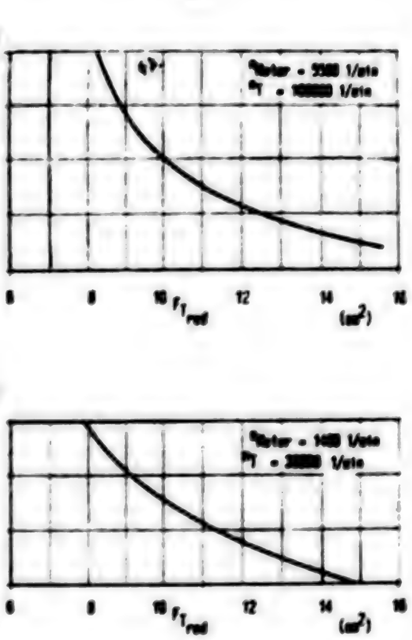


Figure 12: Dependence of the exhaust gas pressure in the exhaust line and of the charging pressure, on the turbine housing cross section, at high and low engine speeds, and on blow-out control on the exhaust gas side

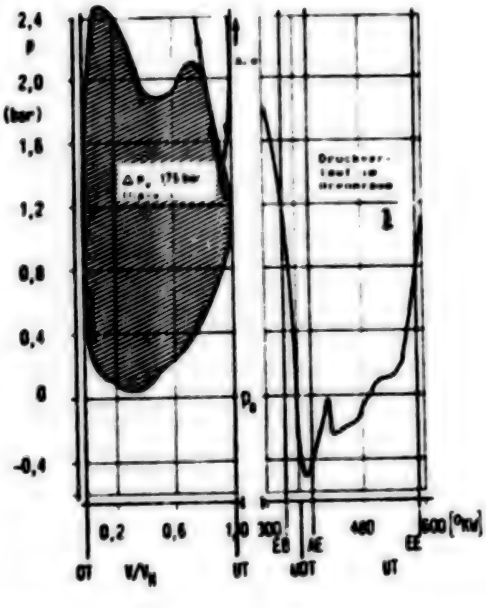


Figure 13: The gas exchange loop of a supercharged Otto engine at rated power

1. Pressure curve in the combustion chamber

To begin with an extreme case, suppose one chooses the turbine and the turbine housing so that the compressor power required for the rated engine power is generated by the turbine with the entire air quantity flowing through the engine that is without blow-off. This condition is shown in Figure 12, top, at the right limit of the curve. This results in the lowest possible pressure before the turbine and consequently the least build-up of exhaust gases. This has all the well-known advantages for gas exchange and cylinder filling.

Unfortunately, this is associated with the worst conceivable creation of charging pressure at low speeds, as Figure 12, bottom, shows at the same point. In order to be able to generate charging pressure at the lowermost speed range of the engine, the narrowest possible turbine housing cross section must therefore be chosen. For example, instead of the above-mentioned $F_{T\ red} = 16\ cm^2$, where the system could run without blow-off, one chooses $F_{T\ red} \approx 8\ cm^2$.

With this choice, a charging pressure of 0.15 bar could already be attained at a motor speed of n = 1400 rpm. The turbine power at high speed, however, would be much too high, because of the severe build-up in the narrow housing cross section.

Blow-Off Control

The turbine power must be reduced to a value that is suitable to generate the desired charging pressure at high speed. The amount of exhaust gas before the turbine must therefore be reduced by means of a so-called blow-off valve. The turbine power is now generated only by a portion of the exhaust gases coming from the engine. This must necessarily lead to a higher build-up of exhaust gases in the exhaust line. In the example shown, the pressure in the exhaust line rises from 1.8 to 2.5 bar. As Figure 13 shows, this causes a high negative gas exchange work, corresponding to a negative average pressure of -1.75 bar. The engine must supply this in addition to its internal output, in order to achieve a desired useful power. But this severely increases the specific fuel consumption.

In the case of the Otto engine, as the pressure rises in the exhaust line before the turbine, the residual mass in the cylinder increases. This reduces the amount of inflowing fresh mixture and furthermore causes considerable heating. This is another reason for high fuel consumption. In order to make sure that the cylinder is filled with an appropriate quantity of fresh gas, the engine must consequently be operated at a higher charging pressure. But this raises the required turbine power and consequently also the counterpressure of the exhaust gases in the exhaust line. In addition, the ignition timing must be delayed, in order to prevent knocking as the

temperature of the cylinder charge increases. This causes a reduction of power as well as higher exhaust gas temperatures, with all its negative effects. One therefore enters an action mechanism, which leads very rapidly to the limit of further supercharging capability of the engine.

At present, the customary design of a supercharged engine for passenger cars has a small turbine housing cross section for the exhuast gas turbine, to create the highest possible charging pressure already at low engine speeds, and to control the charging pressure by blow-off on the exhaust gas side. In the case of the Otto engine, this design is connected with considerable disadvantages from several perspectives, with respect to torque, power yield, or fuel consumption.

If the possibilities of exhaust gas turbocharging are to be used optimally, the Otto engine would require a variable geometry for its turbine housing or a control system with a similar function.

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ASPECTS OF FLUIDIZED BED COMBUSTION OF COAL EXAMINED

Costs, Advantages

Graefelfing ENERGIE in German Jul 79 pp 234-236

[Unattributed article: "Fluidized Bed Burns Everything"]

[Text] Commerical fluidized-bed furnaces are still a few years off. So you want to switch back to coal? If a decision is to be made right away, there is only a possibility then of falling back on the existing conventional furnace and boiler equipment. But fluidized-bed furnaces should also be considered in connection with medium-term planning. This piece of advice comes to us from Dr Hans-Dieter Schilling, acting vice president and head of the coal utilization department at Mining Research, Ltd. At this very moment, two new fluidized-bed furnaces, designed as experimental systems, are going into operation. They will advance developments a good distance toward commercial utilization.

As always, the trouble springs from details and that is also true of fluidized-bed furnaces. Unless it has been proven over a longer period of experimentation that such plants work well, it will be impossible to give any corresponding operational guarantees. That applies also to Babcock and Standard boilers whose design concepts are described in the following two articles.

Where, then, are there any surprises in store for us? We still do not have any adequate experience with big fluidized beds for the industrial sector; as yet, nobody knows how, for example, the heat exchanger clusters, which are dipped into the fluidized bed, will perform, whether there are going to be material problems or whether the coal will be distributed over larger surfaces quickly and well enough. Schilling views future developments quite soberly: "The plants are now going into operation; if we want to prove sufficient reliability and usability, they will then have to run for several thousands of hours at a high availability rate. This implies an experimental span of at least one year. Then we would at the earliest be far enough along

to start the construction of demonstration plants. Depending on the size and the design, we have another interval of one or two years taken up with the construction license and the construction as such so that one may assume that the first plants would be ready for commercial operation in the industrial sector roughly in 1982 or 1983. But that period of time is also needed in order to conduct pertinent advanced planning for corresponding projects with customers.

Lower Emission Values

These plants, which the mining industry hopes will create bigger coal sales, reportedly work in an environmentally safer manner and therefore also more economically. As far as environmental protection is concerned, it has been proven that SO_2 and NO_x emission can be reduced considerably. SO_2 is bound via the added limestone--desulfurization is guaranteed. Dr Schilling: "The experimental results obtained in other countries and in West Germany are encouraging; desulfurization degrees of 95 percent, at a molar ratio of 1:1.6, are technically possible. Of course there is a restriction here to the effect that such favorable results, as they were obtained a short time ago by Mining Research, can be achieved only with limestone from special geological formations which however are available in adequate volumes at least in West Germany. Desulfurization takes place in the fluidized-bed layer already without the addition of limestone: the calcium already contained in the coal will bind between 15 and 60 percent of the sulfur, depending upon the grade of coal we are using. Nitric oxides--we are likewise sure--"remain definitely below the emission values from conventional boilers on account of the low combustion temperatures of around 850° C."

The fluidized-bed layer burns everything: the coal base can be considerably broadened when we use this technique. Says Schilling: "We can charge coal with a high sulfur content, we can use ballast coal which, as we know, can be purchased at a reduced price; but we can also burn high-grade coal. If we use coal with a high ballast content, then the efficiency limit is shifted toward lower numbers of utilization hours. The use of such coals is restricted to areas close to the coal fields since one must take the transportation costs into account."

Fluidized-Bed Furnace 10-20 Percent Cheaper

There is one more question that is as yet unanswered. Will the fluidized-bed boiler be able to get along without electric filters and will fabric filters be sufficient to screen out the dust? The answer involves the costs and, by the way, there are quite a few other points that can influence the economy and efficiency of the entire operation. "I could well image that the investment costs for industrial fluidized-bed boilers would be lower than for comparable conventional coal boilers," notes Schilling who also cites statistics from America, predicting a drop of about 10-20 percent in the investment costs. As far as the fuel-dependent costs are concerned, coal again looks good here as oil prices keep going up.

Anybody who thinks of limestone as a cost factor will have his reservations dispelled by Schilling: "The costs of limestone are comparatively small in the overall balance sheet. Today we are getting a ton of limestone, per truck, free at plant, for about DM25 for use in our experimental plants. If we assume 100 kg of limestone per t of coal, then we would get a cost figure of DM2.50/t. The capital-dependent costs of storage and processing likewise are low. Compared to the cost price for industrial coal, which is around DM150/t, we get about 2 percent of the coal costs.

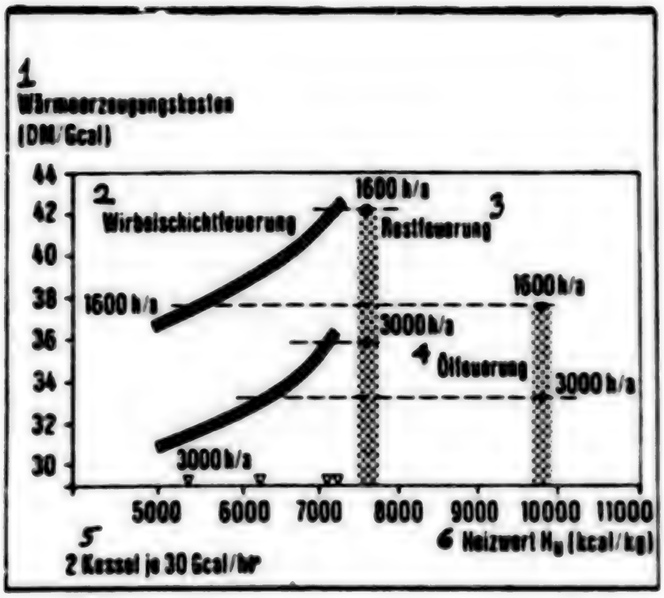
Limestone plus coal does not give us ash but rather residue, the way Schilling puts it. Are there going to be any waste disposal problems? Investigations conducted so far by Mining Research would seem to point to the opposite: "We are optimistic that the material can be sold. Investigations showed that one can use the residues as construction material. The material has a pronounced vacuum structure and is thus heat-retaining and is entirely useful for certain purposes in the construction industry. On the other hand, it will not be too difficult to store the material."

How much of that material is going to come out will depend on the sulfur content of the coal because more sulfur means more limestone and that, in turn, means more residues. Volume problems can certainly also arise which is why residue utilization is likewise a part of the current research program.

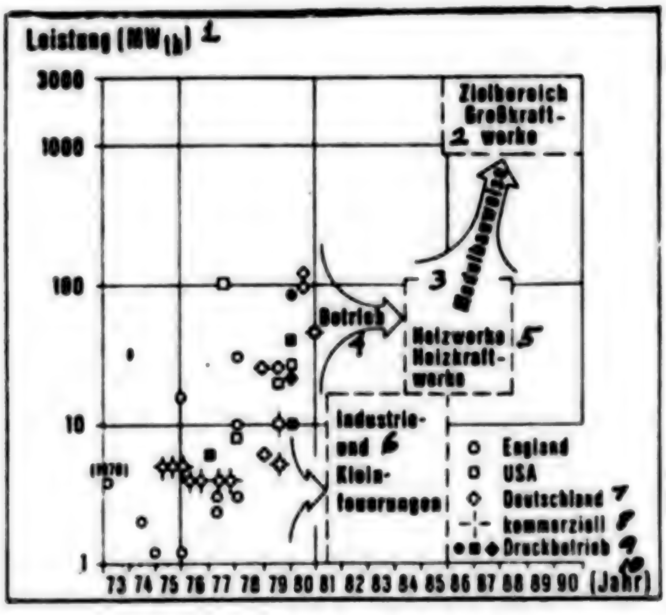
In the experimental plants one must also investigate how the systems can be regulated and how much personnel we are going to need for operation. If we follow Schilling's ideas, then smaller plants should be run without any personnel. At least, we will not need more and better-trained personnel. The fluidized bed can be easily watched, one can introduce thermalelements and one can install pressure probes: the plant will be clearly surveyable and any possible weak spots will be easily recognizable. Schilling is also optimistic as far as partial-load performance is concerned. By means of separate, adjustable cells, one can run the plant at partial load and one will also have leeway by virtue of the fact that the fluidized-bed speed and height can be regulated.

That which applies to industrial plants should also applied to the planned large-scale power plants. But one will not be able to make the fluidized beds in just any size. For large-scale installations we will therefore need a modular design. We will have to wait and see whether systems contemplated here really prove their worth. If this is the case, then we will be able to put up major power plant units with the help of the modular design.

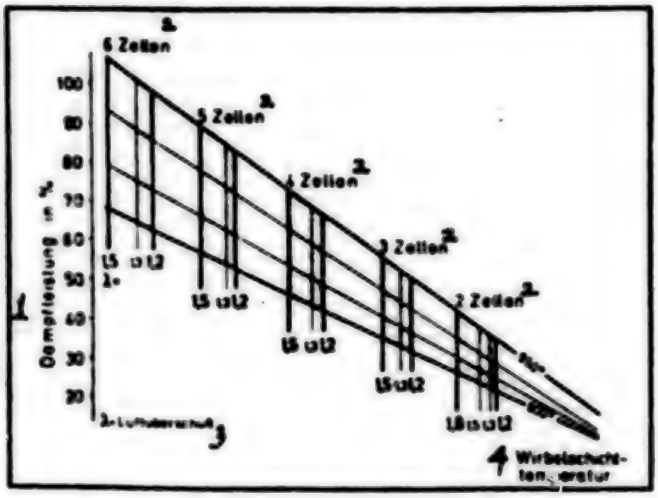
FIGURE APPENDIX



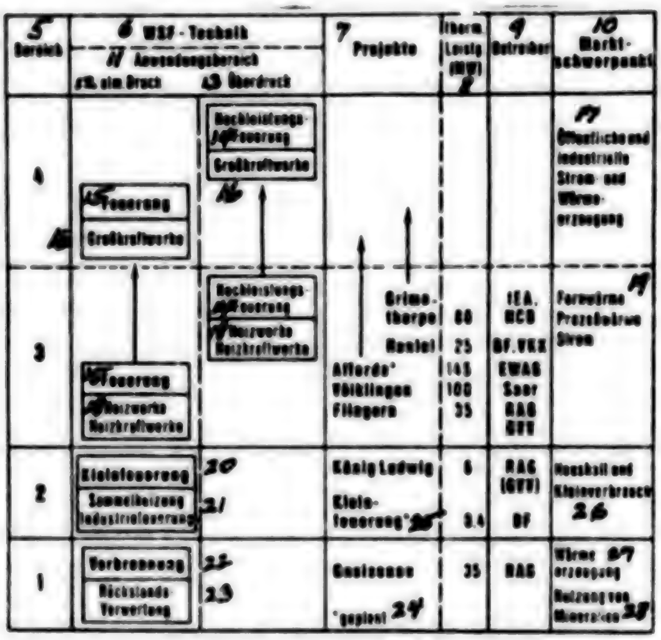
Heat Generation Costs Connected with Various Types of Furnaces.
Key: 1--Heat generation costs; 2--Fluidized-bed furnace; 3--Grate furnace; 4--Oil furnace; 5--Two boilers, each; 6--Calorific value; 7--h/a--hrs/yr.



Significant R&D Installations in England, U.S.A., and Germany; Thermal Output and Year Commissioned.
Key: 1--Output; 2--Target area: large power plants; 3--Modular design; 4--Operation; 5--Heating plants, thermal power plants; 6--Industrial and small furnaces; 7--Germany; 8--Commercial; 9--Pressure operation; 10--Year.



Partial-Load Curves for a Fluidized-Bed Boiler with Six Cells (According VKW [United Power Plants]).
Key: 1--Steam output in %; 2--Cells; 3--Air surplus; 4--Fluidized-bed temperature.



WSF [Fluidized-Bed Furnace] Utilization Areas and Projects.
Key: 5--Sector; 6--WSF technique; 7--Projects; 8--Thermal output; 9--Operators; 10--Major market concentration; 11--Utilization area; 12--Atmospheric pressure; 13--Overpressure; 14--High-performance furnace; 15--Furnace; 16--Big power plants; 17--Public and industrial current and heat generation; 18--Heating plants, thermal power plants; 19--Long-distance heat, process heat, current; 20--Small furnaces; 21--Heating systems, industrial furnaces; 22--Combustion; 23--Residue utilization; 24--Planned; 25--Small furnace; 26--Household use and small-scale consumption; 27--Heat generation; 28--Utilization of minerals.

Use in Steam Boilers

Graefelfing ENERGIE in German Jul 79 pp 236-238

[Article by Engineer W. Voss, chief, central research and development, Standard Boiler Company, Duisburg: "Steam Boilers With Integrated Fluidized-Bed Furnace"]

[Text] Development--trends--problems. The construction phase at the "Koenig-Ludwig" pilot plant containing a steam boiler with integrated fluidized-bed at Ruhrkohle AG [Inc.] is nearing its end. This article explains the development level and the outlook for this new boiler design. The special feature of the plant--to the effect that not only the boiler but also the heat exchanger surfaces are operated in the fluidized bed in a natural cycle--is covered in greater detail.

There are two possibilities of building boiler plants with fluidized-bed furnace:

Building the fluidized-bed furnace into a ceramic combustion furnace with subsequent connected waste heat boiler,

Fluidized-bed furnace built into the body of the boiler.

The "Koenig-Ludwig" plant--which is promoted by BMFT [Federal Ministry of Research and Technology] and which was designed for Ruhrkohle AG by the Thyssen-Engineering Consortium and by Standard-Kessel--we are dealing with a boiler plant with integrated fluidized-bed furnace. At the time the blueprints were being prepared, there was no boiler plant of this kind in Germany as yet.

Wide Bed

The target group for such a plant is industrial operation, as well as heating plants and thermal power plants. To reduce the development time and the risks to a minimum, proven structural components were used to the extent possible; for example, the entire boiler consists of fin pipes that were welded together.

The coal and the limestone needed for desulfurization are stored in storage bins. The desired mixing ratio is adjusted by means of a dosing mechanism and the mixing material is transported to the intermediate storage bunker at the boiler by means of chain conveyors. Three screw conveyors handle further transportation into the fluidized bed where the mixture comes in right above the nozzle floor. Further distribution in the bed is handled by the eddy layer itself through its specific properties and that layer is supported by the decentralized arrangement of the screw conveyors.

To find the best adjustment in terms of height, the screw conveyors are mounted so that they can be adjusted vertically.

This type of charging represents a low-cost solution which is simple in terms of process engineering and which is therefore intended for small and medium-sized plants. In other plants, for example, a pneumatic feed system is used. This method is more expensive but offers the possibility of charging coal, from underneath, through the nozzle floor, into the feed, at any point.

In case of very wide beds, this can result in advantages. In small plants, variously arranged dumping mechanisms are being tested.

New ideas, involving a kind of stoker mechanism in the case of wide beds, were presented at the 6-7 January 1978 VDI [Association of German Engineers] conference on "fluidized-bed furnaces" in Duesseldorf. From the large number of presently tested systems we can tell that coal and limestone supply represent a critical point in the development effort.

Only longer-term operational experience will enable us to decide on the individual application areas for the systems in terms of bed size and coal grain size.

CO into CO_2: Temperature Decides

Special nozzles are built into the flow approach floor of the fluidized bed which is attached to the lower wall collectors. In combination with the adjustable flaps in the air boxes, the nozzles bring about the uniform turbulence of the layer. The wall surfaces are lined with a stamping mass in the area of the fluidized bed. The combustion efficiency is decisive in the evaluation of the furnace; that efficiency is influenced by the unburned coal dust in the flue dust which is evacuated. This situation was already observed in the experimental plants operated with the fluidized bed, for example, in (1).

To keep the flue dust evacuation small, we widen the cross-section in our plant above the fluidized bed (0.8-0.9 m). The attendant reduction of the flue gas velocity leads to a reduced bed evacuation because a portion of the particles gets back into the bed due to the reduced flow forces. This is so important because, in some investigations, for example, W. Poersch, E. Wied, and G. Zabeschek (1), no major increases in the combustion efficiency due to follow-up combustion of the evacuated carbon in the area above the bed were discovered.

This area instead is used for the reoxidation of possibly developing CO in CO_2. To do that, we blow secondary air in via nozzles. Whether and to what extent we get CO will depend on the bed temperature, the carbon distribution in the fluidized bed, and the oxygen needed for the reaction. Bed temperatures of over 700° C prevent major CO formation. The upper limit of the bed temperature is the ash softening point (approximately at 1,150-1,250° C).

Our plant is designed for a bed temperature of 850° C. This gives us an adequate interval to the ash softening point also from the viewpoint of the possible follow-up reaction from CO into CO_2 and the attendant temperature rise outside the bed. We must always expect a slight temperature rise due to the evacuated and still glowing particles.

In starting the plant, the bed material is first heated up with a gas burner to a temperature of about 500° C which is necessary to ignite the coal, before we can charge the coal in. No provision is made for preheating the combustion air. At this ignition temperature we can expect a higher CO content in the flue gases. P. Basu and others reported in (2) that the CO content at temperatures of over 620° C will drop to an insignificant percentage. When starting and turning the system off, we must however go through the temperature range in which we get a higher CO content. In order to get out of this range as fast as possible during the start-up and to facilitate a further reaction of the developing CO and CO_2, the ignition burner should remain in operation also above 500° C. Because of the arrangement of the burner in the front wall, above the fluidized bed, the flue gases flow through a region of higher temperature so that a further reaction is possible.

One disadvantage of the fluidized-bed furnace, as against gas and oil furnaces, is the longer preparation time required for ignition. Most of the ash is evacuated along with the flue gases. For coarser particles there is an ash outlet from the bed. Bypasses and separations of the pipe clusters were adjusted to this circumstance. There is no reason to fear any adhering coatings in the boiler in case of fluidized-bed furnaces (4) so long as the ash particles do not go beyond the softening point. But this is not the case in this particular furnace technique. This is why we built only a comparatively small number of soot blowers into our system.

The dust is removed from the flue gases after the feed-water preheater by means of a hose-filter system. The flue gas temperature should be under 250° C in front of the filter. The boiler is designed for a waste gas temperature of 180° C.

Because of the high degree of sulfur binding of limestone in the fluidized bed (1, 5, 6), we need not expect any major corrosion in the feed-water preheater. It is thus not necessary to raise the feed-water entry temperature, as in the case of an oil furnace, above 102° C. Regarding any subsquent plants, this creates the possibility of further economical waste gas temperature reduction and efficiency increase.

Because of the good heat transfer, about 50 percent of the injected heat are transferred in the fluidized bed to the heat exchanger pipes. If we look at the steam boilers with fluidized-bed furnaces, which have become known, so far, we find that, in these systems, the submerged heating surfaces have a forced-passage throughflow.

Stable Flow

Because the boiler described here works on the basis of a natural cycle, it was obvious to operate the submerged heating surfaces also on a natural cycle. To be able to judge this with the necessary reliability, we conducted stability tests with two variants:

The exchanger pipes were combined in one outlet collector from which the water-vapor mixture is conducted on to the drum in unheated overflow pipes located on the outside;

The exchanger pipes of one pipe disk (four pipes, each) terminate in a larger overflow pipe which is inserted into the boiler wall and which thus continues to be heated all the way to the drum.

These two arrangements differ in terms of the circulation only by virtue of the duration of heating. In the designs chosen, the stability investigation revealed a very stable flow performance for both arrangements. Figure 3 shows the stability characteristic for the exchanger pipes in qualitative terms. We plotted here the pressure loss as a function of the positive, respectively, negative cold-water velocity.

In the computations, we varied the heating from 25 to 400 kw/m^2. Here we obtained cold-water velocities of about 0.5-0.8 m/sec. In this way, the submerged heating surfaces in boilers of this design can be operated without difficulty on a natural cycle. The advantages of the natural cycle--no operating costs and high operational safety--thus can be used also in connection with this structural component. Solution 2 (Figure 2) was implemented on the basis of the design advantages.

The corrosion and erosion behavior of these submerged heating surfaces is particularly interesting. At the cold-water speeds given, we can guarantee the proper cooling of the pipes so that the pipe wall temperature will be just a little bit above the operating temperature. This is why the utilization of St 35.8 [steel] is adequate.

In this plant however we have various raw materials (St 35.8, 15 Mo 3, 13 CrMo 44, 10 CrMo 910) in order to learn more about their performance during the experiments. In their experiments, M. J. Cooke and E. A. Rogers (3) observed a material loss of 20 mg/cm^2 after 1,000 hours and at 400° C when a simple carbon steel was used. On the other hand, in a steel grade with 12 percent chrome, one can observe a material loss of only 1 mg/cm^2. The experiments must clarify which of these generally available boiler construction steel grades are best suitable for the submerged heating surface. Because we are dealing here with a relatively small surface, in other words, about 10 m^2, the material price plays a subordinate role.

The significance of this type of furnace as far as coal is concerned, environmetal protection, and the economy of steam generators once again becomes recognizable as we list its advantages:

Low combustion temperature,

No contamination problems in the heating surfaces,

Possibility of using a wide fuel assortment (inferior coal, coal with a higher content of fines and coal with a high ash content can be burned),

Reduced NO_x emission due to low contamination [sic] temperature,

Extensive desulfurization in the fluidized bed,

Small construction volume,

Low investment costs,

No follow-up treatment of flue gases necessary to maintain the capital TA [Industrial Operation Requirements] air, except for dust removal,

Lower operating costs,

More reliable fuel supply.

There are also some disadvantages resulting from the use of coal:

Longer ignition,

Expensive storage,

Greater operating expenditure,

Poorer regulating [adjustment] performance as compared to oil and gas furnaces.

But in view of the current energy situation, in terms of supply and cost, the fluidized-bed furnace offers not only an equivalent alternate solution but also entails considerable advantages. We must not forget that we can expect a steady price rise on the coal market. According to recent experience, this certainly cannot be predicted for the oil markets. Statistics on steam boilers with coal furnaces installed in West Germany show that a considerable portion will over the next several years have to be replaced for reasons of age. Without fluidized-bed combustion it is doubtful whether coal will retain this share of the market. On the other hand, if the tests on the pilot plants turn out positive, we can expect rapid introduction into the market.

I assume here that the coal suppliers will actively support the boiler operators who decide to install such a system.

The activities of Standard-Kessel regarding fluidized-bed furnaces are presently concentrated in the "Koenig-Ludwig" pilot plant and the

development of a project study. The latter will be used for designing a planned thermal power plant and will be carried out together with our Consortium partner Thyssen-Engineering and the Schmidt-Reuter Company.

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FIGURE APPENDIX

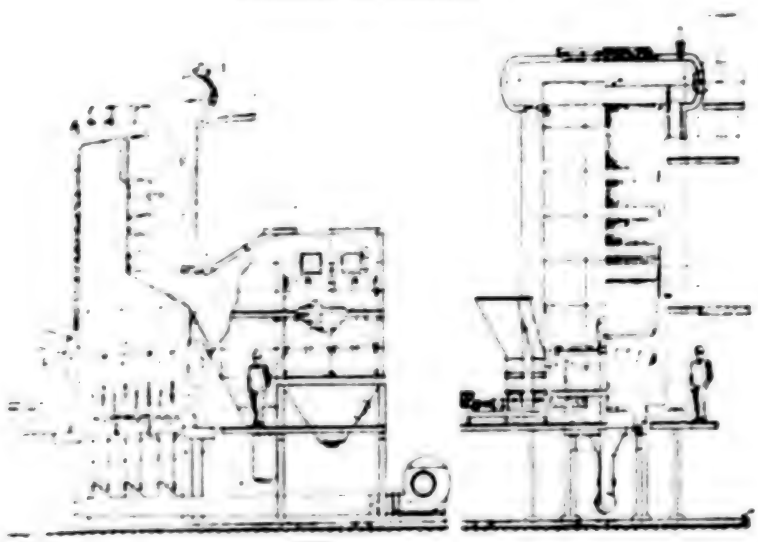

Figure 1. Natural-Cycle Boiler with Fluidized-Bed Furnace; Steam Output 8.85 t/hr, Pressure 17 bars, Temperature 204° C.

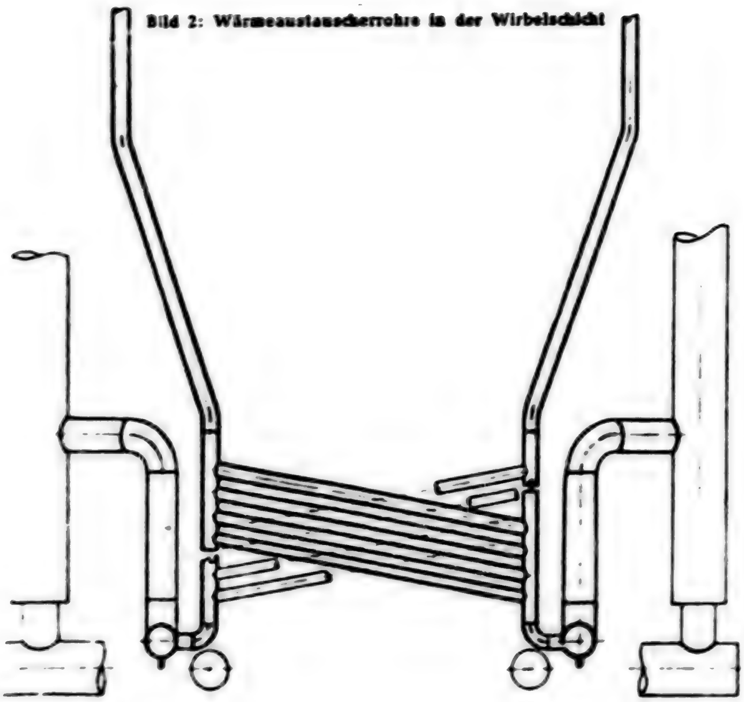

Figure 2. Heat Exchanger Pipes in Fluidized Bed.

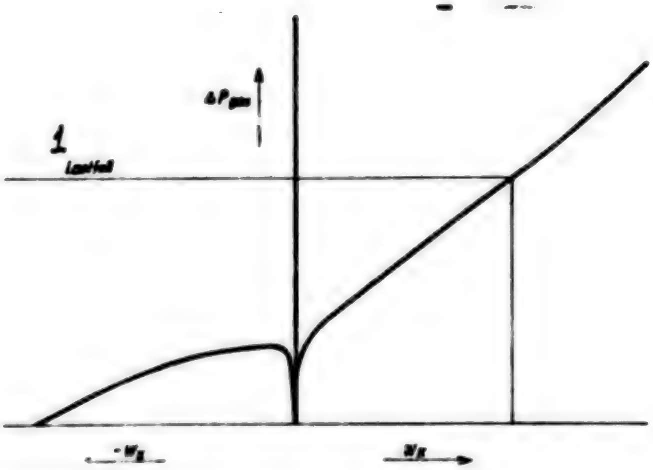

Figure 3. Stability Characteristic for Heat Exchanger Pipes in Fluidized Bed.
Key: 1--Under load.

Environmental, Operating Advantages

Graefelfing ENERGIE in German Jul 79 pp 240-243

[Article by Dr-Engineer Hermann Brandes, Deutsche Babcock AG, Oberhausen: "Environmentally-Safe Steam Generators with Fluidized-Bed Furnace"]

[Text] The technique involved in electric current and heat generating plants is today essentially determined by the requirement for the minimum possible environmental pollution and economical use of primary energy. At the same time, the harmful-substance content of fuels keeps increasing because of the intensive exploitation of deposits. Besides, easily handled primary energies, such as gas and oil, can be used only to a very limited extent because of the anticipated shortage and in some countries they must no longer be used in energy conversion plants. This further raises the requirements for furnace systems in terms of emissions.

Coal, especially also inferior-quality coal, with a high ash content and much sulfur, coal processing products, such as flotation slurry, oil shale, as well as community and industrial waste will in the future be used on a preferred basis for the generation of current and heat. The fluidized-bed furnace is suitable for this because:

No thermal nitric oxide (NO_x) is generated on account of the low combustion temperature of 800-900° C;

Most harmful substances are not evaporated but remain in the ash, for the same reason;

When we use coal, the binding of the sulfur, to the extent of more than 90 percent, to lime charged in simultaneously with the coal and its evacuation with the ash are made possible so that extensive flue gas treatment procedures become superfluous;

One can charge moist and, in the extreme case, even sludgy solids;

Ash-rich and difficult-to-burn fuels as well as salt-containing coals can be charged;

The corrosion or caking on the firing chamber side is heavily reduced on account of the low combustion temperature;

There is no ash melting on account of the low combustion temperature so that the ash reveals a favorable erosion performance.

So far we have no generally valid rules and guidelines and no binding mathematical models available for the design, dimensioning, and construction

development of fluidized-bed furnaces and their subsequently connected subsystems. Bases for design are being obtained through experiments in pilot plants or laboratories. In the construction effort we furthermore take into account experiences with plants employing the same technique although process control is different. Here we fall back to tried and proven detailed designs and system concepts.

The basic structure of the fluidized-bed furnace and its operating procedure were explained in many instances before, among others, in (1, 3). We will therefore not go into this here in any greater detail.

35-Mw Steam Generator of RAG with Hard-Coal Fluidized-Bed Furnace

At the Flingern Power Plant of the Duesseldorf Municipal Power Plants, Inc., and existing grate-furnace steam generator was converted to fluidized-bed operation (2, 3) for RAG (Ruhrkohle AG). In keeping with the original boiler output, about 50 t of steam are generated every hour at a coal charge rate of about 6 t/hr and are fed into the power plant's steam system. The plant is currently being placed in operation.

To explain the process-engineering setup for the 35-Mw plant in Flingern, we have a simplified flow chart and an installation plan in Figure 1.

Planned 35-Mw Steam Generator of RAG with Flotation Mound Fluidized-Bed Furnace

The waste dump problem and fuel price rises were the motives for the development of a new technology to be used in connection with flotation mounds with the following objectives:

Burning flotation mounds also with a high water and ash content in a fluidized bed,

Accomplishing combustion also at high sulfur content in an environmentally safe manner and

Utilizing the developing process heat for steam generation.

The thermal output of the planned installation (4) is 35Mw and the steam output is 30 t/hr. The installation is to take over the base load of steam generation in a [coal] mine power plant which would supply the shaft system and the coking plant with steam, compressed air, and heat.

The fuel for the fluidized-bed installation has a water content of about 30 percent by weight. The ash content averages 40 percent by weight of raw substance. The water-free fuel has a calorific value of just about 13,000 kJ/kg or 3,100 kcal/kg. Additional data on the makeup of the individual components and the weight of the fuel can be seen in the table.

Fuel Charge	Unit	Flotation mounds	Pond slurry	Total
Combustible substances	kg/hr	2,406	1,563	3,969
Ash	kg/hr	4,641	786	5,427
Water	kg/hr	3,060	1,020	4,080
Sulfur	kg/hr	93	31	124
Sum	kg/hr	10,200	3,400	13,600
Calorific value i wf [Thermal flow]	kJ/kg	9,818	22,441	12,974

Flingern Data

Coal throughput	appr. 6 t/hr
Steam generation	appr. 50 t/hr (17 bars, 400° C)
Air index	= 1.3
Flue gas volume	appr. 60,000 m^3/hr
Fluidized-bed surface	24 m^2
Fluidized-bed height in operation	1.3 m
Fluidized-bed height at rest	0.8 m
Turbulence speed	max. 2.6 m/sec

At an hourly charge rate of 10.2 t of flotation mounds and 3.4 t particle slurry, with sustained operation of more than 8,000 hours per year, the entire waste from these fuels is eliminated and utilized in the shaft installation.

Figure 2 shows the simplified flow chart and an installation plan for the plant with separate furnace and steam generator.

Comments on Future Developments

The future development of the fluidized-bed technique is aimed at the simplification of structural components with retention of all advantages of this furnace principle as well as optimization of the efficiency of the entire process and the dynamic performance, including start-up, partial-load operation, and intermittent operation.

An analysis on possible simplifications and improvements for coal-fired plants shows that they are possible particularly in the area of the fluidized bed because otherwise conventional equipment, proved in connection with steam generator construction, would be used in the entire plant. One must above all try to achieve simplified fuel injection in terms of type and numbers. So far, we have been selecting a rather conservative figure with a fuel [injection] nozzle, per square meter, amounting to a maximum of about 2 m^2. The results in Flingern will have to tell us whether we can charge a larger surface with one nozzle. The expenditure for the total fuel injection phase would then be correspondingly reduced.

A mechanical fuel supply system would have the advantage that one could get along without the drying required for pneumatic conveyance. That would be particularly good for small plants because the fuel is injected into the fluidized bed from the side, for example with worm gears. In larger plants, the fuel could be stoked [projected]. This leads to poorer burnout and desulfurization degrees due to the immediate spread of fine particles. The elimination of drying, the low in-house requirement, as well as the possibly lower expenditure for fuel charging would be advantageous on the other hand. Just exactly what kind of fuel supply is best can be determined only from one case to the next on the basis of the specific parameters (fuel price, efficiency, environmental safety requirements, etc.).

The plant could furthermore be simplified by eliminating the ash return. The resultant deterioration in the burnout could be compensated for entirely or in part by means of a higher fluidized bed. The plant's in-house requirements would go up accordingly because of the greater pressure loss. Here again, the various possibilities must be weighed against each other from one case to the next.

Can Be Built Up to 200 Mw

Considering the results at the Flingern Plant, it seems that one can build steam generators with fluidized-bed furnaces for hard coal with a steam output of up to about 200 Mw. Planning studies for plants with intermediate superheaters revealed difficulties in the subdivision of the intermediate superheater heating surfaces. Arranging the terminal phase in the fluidized bed leads to a very complex bed subdivision with corresponding difficulties in terms of fuel charging and adjustment, especially in case of partial load. Something similar applies when only evaporator and superheater heating surfaces are arranged in the bed and when we use a superheater-intermediate superheater-heat exchanger. If the entire intermediate superheater is arranged in the form of convective heating surfaces, the latter become very large. Besides, we get a poor intermediate superheater characteristic. Plants with intermediate superheaters must possibly be designed entirely differently from the steam generators, with fluidized-bed furnaces, which have been built and planned so far. Work is being done on these concepts.

Plants with very moist fuel, such as flotation mounds, should be equipped with mechanical charging devices because one may well assume that the particles,

which for example are formed by chain separators from the fuel flow are decomposed into the original grain only as they become submerged into the fluidized bed so that premature evacuation is impossible. A simplification and improvement of the concept involved in the demonstration plant seems possible by switching to an integrated design. We would get a situation similar to the 100-Mw concept for hard coal furnaces. By way of an alternative, we might think in terms of a reversing [two-way flue] steam generator with bulkhead superheaters in the transverse flue. The membrane wall design would considerably improve the plant's dynamic performance. Burnout difficulties due to excessively cold combustion resulting from cooling by the membrane walls could be eliminated by studding and stamping the walls. The integrated plant would be compact and simple in terms of construction. That would result in favorable values for the heat losses and the investment costs.

If we compare steam generators with fluidized-bed furnaces and dust furnaces, we presently still get investment costs for the fluidized-bed furnace plant which are about 10-20 percent higher, assuming the same delivery volume. This is essentially due to the safety surcharges, especially when it comes to fuel charging, ash return, and heating surface design. Identical or lower costs should be attainable as the design reliability grows. Here we consider the fuel route starting at the raw coal bunker, the water-steam route starting at the feed water valve up to the high-pressure steam outlet, the complete air supply, as well as the flue gas route to a point in front of the filter. In dust-fired steam generators, we have so far been using mostly E-filters. For fluidized-bed fired plants, one should prefer fabric filters because E-filters would become very large and thus also expensive on account of the high desulfurization degree. The operating costs as a whole however are practically the same because of the higher pressure loss in the case of the fabric filter.

In any cost comparisons one must keep in mind also the increased in-house requirement due to the higher pressure loss in the fluidized bed as compared to coal dust burners. This can be compensated for through less grinding and the lower flue gas temperature which is possible because of the sulfur-poor gases.

Definite cost advantages for the fluidized-bed-fired steam generator result when we consider the costs for structural components to comply with titer environmental protection requirements. Low nitric oxide emissions can be attained only with a very complex burner structure, larger than usual combustion chambers, and possibly additional flue gas recirculation to be built in when we use conventional dust furnaces; those lower nitric oxide emissions however are always still a little bit richer in so-called thermal nitric oxides than those from the fluidized-bed-fired plants. Regulations on limiting SO_2 emissions have a far stronger effect. The investment costs for flue gas desulfurization systems can come up to the cost level of steam generators if the flue gases are to be purified up to 100 percent with an efficiency of 80 percent and more and if reusable products are demanded. In addition we have the operating costs for additive substances, in-house requirements, and possible reheating of flue gases.

Cost advantages emerge for the fluidized-bed furnace in a pattern increasing along with the increase in the annual utilization hours if cheap, ballast-containing coal is offered--the kind of coal that cannot be burned in a dust furnace.

The comparison of fluidized-bed-fired plants with steam generators equipped with grate furnaces for coal and with oil-fired steam generators leads to similar results (1). To be sure, the oil-fired plant in particular reveals lower investment costs but higher fuel prices above all in the case of oil create a situation where the fluidized-bed-fired steam generators operate at higher cost only at peak load and with top-grade coal.

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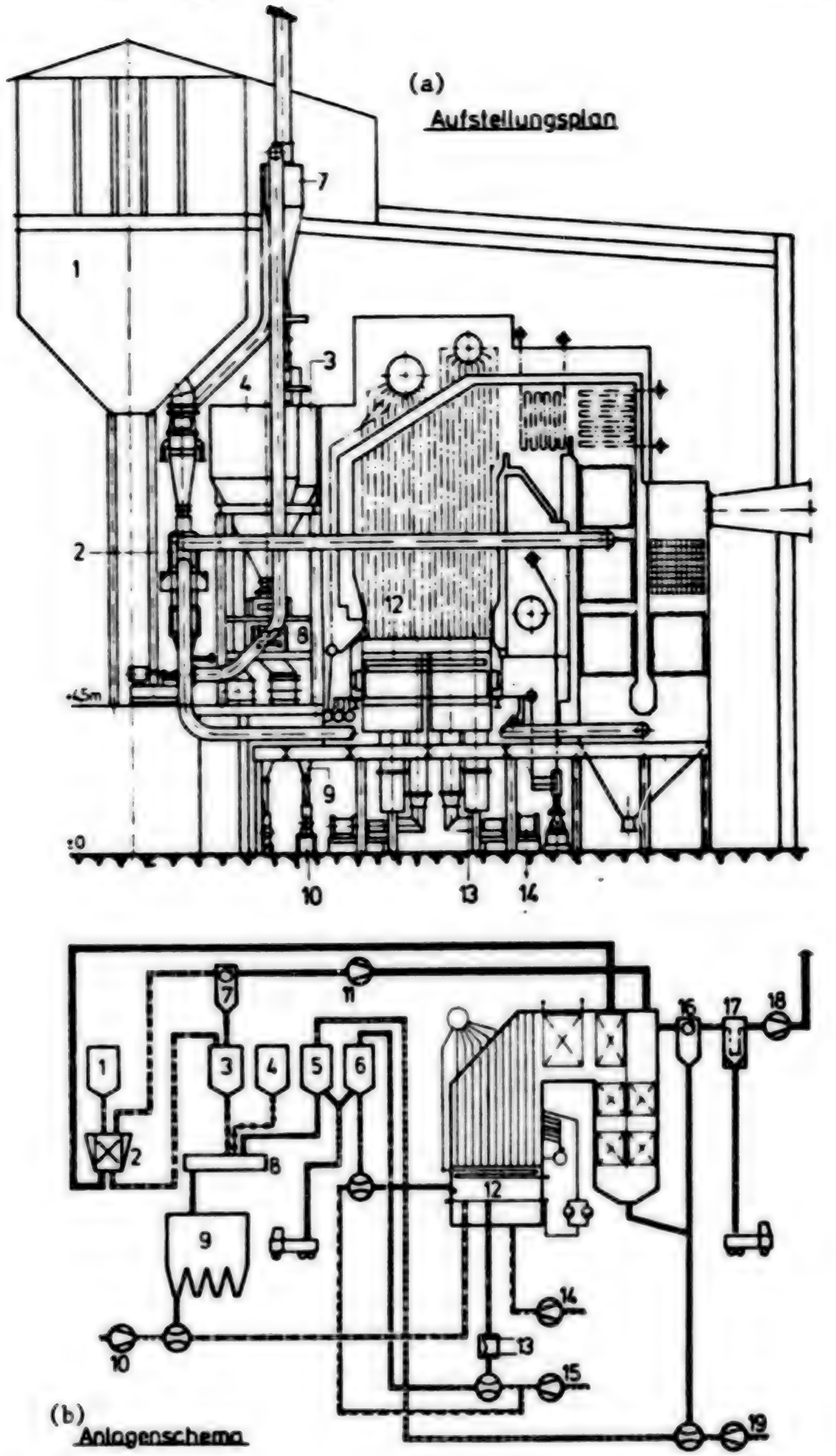

Figure 1.
[Caption and key to Figure 1 on following page]

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Figure 1. 35-Mw Steam Generator of RAG with Hard Coal for Fluidized-Bed Furnace. The raw coal is crushed in a coarse reduction impact crusher down to a grain size of < 6 mm and is simultaneously dried to a residual moisture of about 4 percent with flue gases which have a temperature of 400° C and which are returned from the steam generator. From the ready-material bunker, the coal is conveyed via bucket-wheel locks and a dosing conveyor scale to the pneumatic conveyor system in a well-defined quantity. Depending upon the desired desulfurization degree, fine-grained limestone is simultaneously taken out of the limestone bunker and added to the coal current in a mixture.

The coal-and-limestone mixture is transported to the fluidized-bed floor with the help of the conveyor air and is charged into the fluidized bed via special coal nozzles.

The combustion air, which simultaneously serves as the eddy medium, is forced from the air boxes, placed below the fluidized-bed floor, into the combustion chamber via numerous air nozzles. The combustion chamber is subdivided into four fluidized-bed segments which can be separately supplied and regulated in terms of fuel and air. As a result of that, the start-up and shut-down processes can be simplified in an advantageous manner and the plant can be run at partial load by turning off individual cells.

The turbulence floor and the surrounding walls are made in the form of welded membrane type walls.

Into the approximately 1-m high eddy layer, there are submerged evaporator type clusters which are operated on a forced-cycle basis and which absorb about 50 percent of the heat generated; they guarantee a limitation of the combustion temperature to figures between 750 and 900° C, depending upon the load and the type of coal. The flue gases, which leave the fluidized bed at the corresponding temperature, are cooled off in the conventional portion of the three-flue steam generator down to 180° C and are then fed to the dust removal component. The flue gases are purified in two stages in two parallel-connected cyclones and in a subsequently connected fabric filter.

The flue dust, which is separated in the cyclones and in the bypass between the second and third flue, is pneumatically conveyed into a separate chamber in the ash bunker. This dust can contain more or less unburned carbon depending upon the operating conditions that were actually employed. This flue dust can be returned into the fluidized bed to increase the total burnout.

If the coal contains less than about 12 percent ash, then more ash is evacuated upward than is supplied, below, through the fuel. To stabilize the bed, we then need an ash return.

The fluidized-bed pocket is evacuated via outlet pipes along the floor of the fluidized bed and is indirectly cooled down to 200° C in specially designed ash coolers. After that it is conveyed pneumatically into the ash bunker.
[Continued on following page]

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Key: (a) Installation plan; (b) Installation diagram; 1--Raw coal bunker; 2--Mill; 3--Coal bunker; 4--Limestone bunker; 5--Bed-ash bunker; 6--Flue-ash bunker; 7--Dust separator (coal); 8--Mixer; 9--Distribution bunker; 10--Blower for fuel conveyance; 11--Blower for mill exhaust air; 12--Fluidized-bed combustion plant; 13--Ash-cooling chamber; 14--Blower for combustion air; 15--Blower for ash conveyance; 16--Dust separator (after boiler); 17--Hose filter; 18--Suction blower; 19--Blower for ash return.

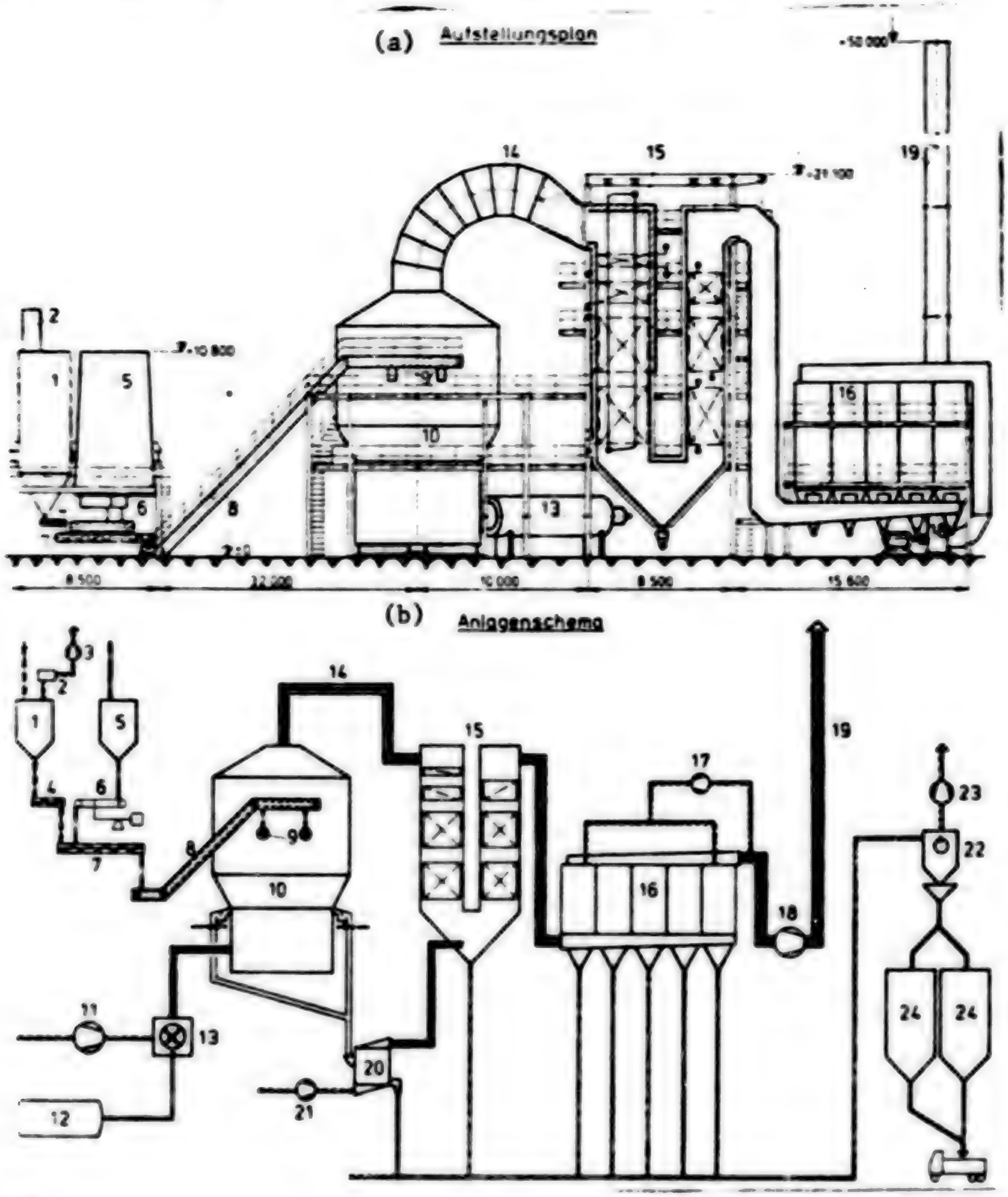


Figure 2.

[Caption and key on following page]

[Caption and key to Figure 2 on preceding page]

Figure 2. Planned 35-Mw Steam Generator with Flotation-Mound Fluidized-Bed Furnace for RAG. The flotation coal and the lime are taken from the particular bunkers and are conveyed to a double-shaft mixer via dosing conveyor belt scales. At the end of the double-shaft mixer, the product current is placed upon the diagonal conveyor belt and is then subdivided into two volume currents.

These currents run into the chain separators which hurl the fuel into the furnace, distributed over a larger scatter surface.

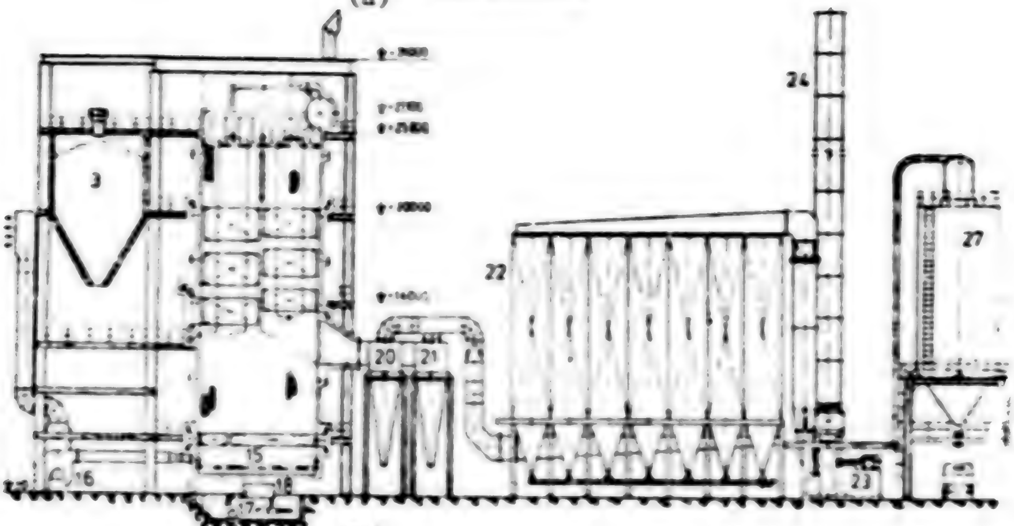
The ash is taken out via two ash evacuation pipes located in the flow approach floor and is then cooled in the ash cooler.

The flue gases from the combustion furnace are fed to the separately established steam generator through a stamped pipeline. The heating surfaces of the waste heat boiler are placed in two flues which are connected in after the furnace on the flue-gas side and which are designed as horizontal pipe clusters. About 10 percent of the evaporation heating surface are located in the fluidized bed of the furnace and absorb 60 percent of the total evaporator output. That again comes to about 40 percent of the total heat output from the furnace used here.

After the steam generator, the flue gas is conducted to a hose filter for dust separation. The flue dust separated in the filter is evaporated via bucket-wheel locks. After that, the flue gas is conducted via a radial suction flue blower through the chimney into the atmosphere.

Key: (a) Installation plan; (b) Installation diagram; 1--Lime bunker; 2--Bunker ventilation filter; 3--Blower for bunker exhaust air; 4--Dosing worm gear; 5--Flotation mound bunker; 6--Belt scale; 7--Mixing worm gear; 8--Tray chain conveyor; 9--Chain separator; 10--Fluidized-bed combustion furnace; 11--Fresh-air fan; 12--Oil tank; 13--Hot-gas generator; 14--Hot-gas pipeline; 15--Waste heat boiler; 16--Fabric filter; 17--Blower for rinsing air; 18--Suction flue; 19--Chimney; 20--Ash cooler; 21--Blower for cooling air; 22--Cyclone dust separator; 23--Blower for ash conveyance; 24--Ash bunker.

(a) Aufstellungsplan



(b) Anlagenschema

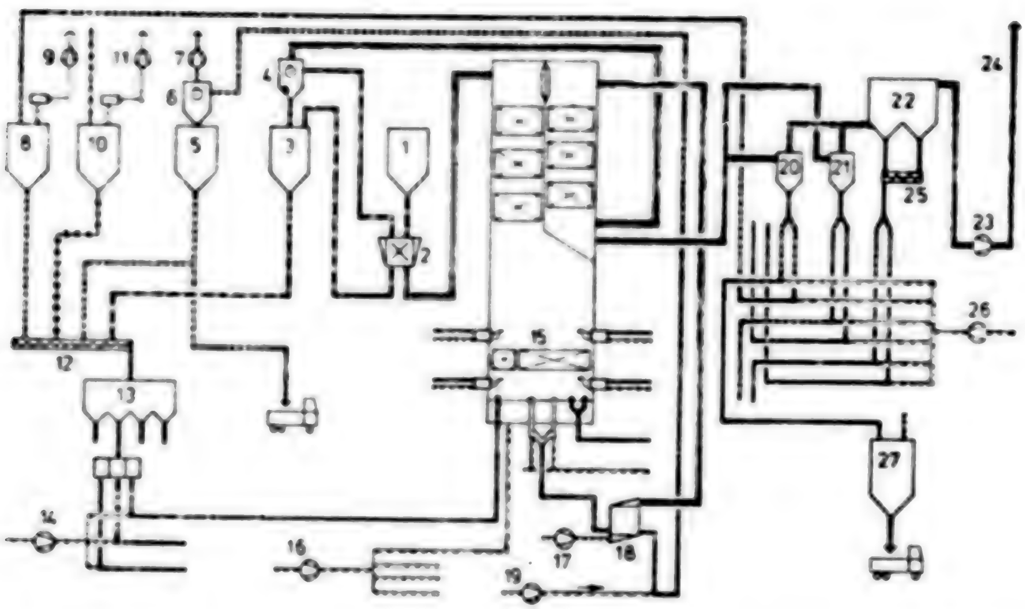


Figure 3. 100-Mw Steam Generator with Fluidized-Bed Furnace for Hard Coal. 100-Mw steam generator for coal furnace.

Figure 3 shows the flow chart and the installation plan for the plant. Raw coal is moved from the raw coal bunker into the crusher where it is ground to a grain size of less than 6 mm and where it is dried at the same time. The necessary drying heat is directly taken from the steam generator after the first flue, the flue gases cooled in the crusher are again piped into the flue gas current after the second flue.

The prepared fuel and the lime are taken from the bunkers by means of bucket wheel distributors, they are homogenized in a worm gear mixer and they are

[Continued on following page]

[Caption and key to Figure 3 continued from preceding page]

placed in intermediate storage in a mixture bunker. If necessary to improve the burnout or to stabilize the bed, one can add flue ash to the solid material current in front of the mixer. The prepared solid material current is pneumatically blown into the fluidized bed from below after intermediate storage in the mixture bunker.

The bed ash is taken out of the bed from below and is cooled in the ash cooler. The heat taken out of the ash is supplied to the boiler and the ash itself is stored in the bed ash bunker.

The steam generator is a membrane-welded two-flue steam generator with forced circulation (La-Mont System). Membrane pipe walls also subdivide the fluidized bed into four bed segments. The membrane walls and three quarters of the submerged heating surfaces are made in the form of evaporators, while the subsequently connected heating surfaces are made as superheaters and Eco. In our case here, one quarter of the submerged heating surfaces is connected as superheater because, considering the design data of 100 bars and 530° C, the heat given off in the fluidized bed can no longer be absorbed by the evaporator alone. The superheater located in the fluidized bed is placed in operation only after adequate through-flow has been guaranteed.

The flue gas speeds are limited in all steam generator heating surfaces to less than 10 m/sec. The heating surfaces are executed in a tapered arrangement. The steam generator is equipped in the area of the cluster heating surfaces with longitudinal screw blowers. In this way we can guarantee minimum wear and tear coupled with optimum heating surface cleanliness.

After coming out of the steam generator, the flue gases are evacuated into the atmosphere via two parallel connected cylones and the fabric filter. The separated flue ash is pneumatically conveyed into the flue ash bunkers.

Key: (a) Installation plan; (b) Installation diagram; 1--Raw coal bunker; 2--Crusher; 3--Coal bunker; 4--Separation cyclone; 5--Bed ash bunker; 6--Separation cyclone; 7--Waste air blower; 8--Flue ash bunker; 9--Exhaust air blower; 10--Lime bunker; 11--Exhaust air blower; 12--Mixing worm gear; 13--Mixture bunker; 14--Blower for mixture conveyance; 15--Fluidized-bed furnace; 16--Fresh-air fan; 17--Blower for cooling air; 18--Ash cooler; 19--Blower for bed ash; 20--Cyclone dust separator; 21--Cyclone dust separator; 22--Cloth filter; 23--Suction flue; 24--Chimney; 25--Worm gear conveyor; 26--Blower for ash return; 27--Flue ash bunker.

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ADVANTAGES, PROBLEMS OF DIGITAL AUTO COMPUTERS DISCUSSED

Hamburg DER SPIEGEL in German 10 Sep 79 pp 257, 260

[Text] At the automobile show in Frankfurt an outsider is presenting something that the large concerns still are not in a position to offer: electronic instruments that indicate automatically.

Out of the city, onto the autobahn--until recently Rainer Buchmann, owner of a company, thought this was the fastest and most sensible way to get to the airport from his plant in Frankfurt's Bornheim section. Buchmann has wasted a lot of time and gasoline because it is faster and more economical to go right through the middle of the city.

This driver of a Porsche owes the discovery, which is accurate to a tenth of a liter, to minutes and to a tenth of a kilometer, to an electronic apparatus the size of a cigar box hidden behind the dashboard. Buchmann is going to introduce it as an "International Innovation" at the automobile show in Frankfurt that starts on Thursday of this week and intends to offer it soon to drivers to install--the first dashboard with fully electronic components for automobiles.

"This is the future." That is how the 33-year old head of a small, but imaginative company (B+B) for exclusive automobile accessories interpreted his "Dinfos"--the device is so-named from "digital-information-system." Buchmann explains how it is that he, and not one of the big companies in the automobile or electronics industry, was the first to get close to this future: "We recognize the trend, observe where things are dragging, we are more flexible and can react more quickly."

Extra electronic devices ("panel computers") as a supplement to the traditional, mechanically designed indicators for automobiles have been available for some time, for example from BMW [Bavarian Motor Works], Cadillac or even in the "Horizon" from Jedermann-Auto. But these extras require increased attentiveness on the part of the driver--the driver has to try to catch the numbers, which flash green and light up on special call, by pushing buttons and with a quick side-glance.

In Buchmann's opinion "the others have all basically just hung a pocket computer into the automobile. The ADAC [General German Automobile Club] saw in them less of a useful accessory, but more a kind of "satisfaction of the play instinct."

On the other hand, Buchmann pursued a concept, on which, for example, the engineers at Daimler-Benz were also working: digital indication, large and clear in the field of vision, continuously shows the driver the most important values--but in addition, if a malfunction is in the offing, it also automatically provides the appropriate warning signals without pressing and turning any buttons.

A head electronics engineer at Daimler-Benz, Inc, stated that "the driver should be looking at the street; we view a 10-key computer on the dashboard as a safety risk." Since the Mercedes managers do not yet consider their development ready for marketing, they are still holding it back.

In the meantime, the flexible 16-man company in Frankfurt succeeded where the big companies could not--to be sure only after an almost 16-year headstart. Since 1973, from one oil crisis to the next, Buchmann has been pondering how "a new relation to the automobile" could be introduced with electronics.

The head of the company, his brother and partner Dieter, 28, and designer Eberhard Schulz, 30, had started by improving the tones, shapes and colors of the automobile. The company made sales in the millions by dressing up mass-produced automobiles: the Buchmanns charge DM4,200 to install a stereo system, DM16,000 for a car-telephone. A Porsche Targa Turbo, which Porsche itself does not even have available in its line, would cost about DM70,000 more.

But the Hessian price giants were not in a position to risk the "jump into the real technology" of an automatic, electronic information system until sufficiently sturdy microprocessors were available. Electronics engineer Peter Roggenkamp, 34, who was signed up to develop the "Dinfos," contrived such a clearly organized system for it "that every technically naive housewife even understands the thing."

Located on main panel in full view of the driver, the "Dinfos," which is divided into three sections, continuously shows with illuminated red digits the basic information necessary for driving, for example, speed, kilometers driven, turn signal control. At the same time, the two side sections on the console provide dozens of bits of data which the driver need not absolutely have under constant control.

Nevertheless, important "secondary values" do show up lightning-fast as emergency information on the main panel in the visual range of the driver, as soon as a malfunction threatens--whether it is a really dangerous drop in oil pressure or a plunge in the temperature warning of ice. Dinfos even can report the vehicle weight (and any overload).

Buchmann intends to offer the system to drivers who desire such luxury at prices between DM4,000 and DM5,000. The next step in development is of course already programmed: they say that before long electronics will whisper its warnings to the driver in human language.

12124
CSO: 3102

REORGANIZATION OF NATIONAL RESEARCH OFFICE OUTLINED

Organization, Manning

Paris AFP SCIENCES in French 13 Sep 79 pp 1,2

/Article: "Policy and Organization of Scientific Research," on reform of National Center for Scientific Research--CNRS/

/Text/ Paris--Reform of CNRS--Three decrees relating to the organization, the national committee, and the financial regime of the National Center for Scientific Research (CNRS) were published in the 12 September JOURNAL OFFICIEL thus putting into effect the reform of the CNRS which the scientific world had been awaiting for several months.

Meanwhile, at the end of last July, the Ministry of Universities had disclosed the general lines of the reform, before transmission of the texts to the Council of State, thus provoking a mobilization of the researchers' unions, whose sections within the FEN and CGT /General Confederation of Labor/ called a demonstration on 14 September in front of the College de France in Paris, to protest against the "dismantling of the CNRS.

Concerning the organization of the center, the decree puts an end to the bicephalous structure of the direction (scientific general director and administrative and financial director) in favor of a single general executive direction, with a general director assisted, for the administrative and financial management, by a general secretary and by scientific directors in charge of following the evolution of different sectors of research. All these personalities are appointed either by a decree of the Council of Ministers--on the recommendation of the minister of universities--or by an order of that same minister.

The main orientation of the scientific policy of the center is determined by the council and its president. The decree reduces to 15 members--instead of 28 previously--the composition of the council. Aside from the 5 ex officio members, all of these are appointed by decree of the Council of Ministers. In the preceding statue the council included 10 persons elected from its own membership by the Directoire, a form of indirect representation of the National Committee.

Among the 10 personalities appointed to the council, four are chosen because of their competence in the field of industrial and applied research, and six for their scientific accomplishments--the former by recommendation of the Academy of Science, and the latter on that of the College de France.

Finally, special mention is made of the national institutes, such as the National Institute of Geophysical Astronomy (INAG) and the National Institute of Nuclear Physics, which have distinct organizations and budgets, and which form the "CNRS Group." The decree provides for other institutes to be allowed to take charge of several existing laboratories: The Institution of Data Processing and automation research (IRIA) could be one of them.

A particular decree deals expecially with the National Committee, "a little parliament of research." It indicates that the sections of that committee have 23 members, of whom 15 are elected from their own membership by 3 electoral colleges (one university, one center scientist, one engineer), from which are excluded--both as candidates for election and as electors--the technicians and administrative personnel, regrouped with the college of engineers of the former statute.

The Directoire--a 42 member consultative organ for synthesis which carried forward the action of the National Committee--becomes, according to the first decree, a scientific committee of 17 members, among whom not one is chosen by direct election (16 members according to the former system).

Finally, the decree dealing with the financial regime of the CNRS indicates that the center's budget is presented with a simplified itemization--determined by a decree of the minister of universities, the secretary of state for research and the minister of the budget--providing for double classification of operations according to their nature and their destination.

The reform--announced a year ago--of this enterprise involving more than 22,000 people (8,295 researchers in 79), with a budget amounting, in that same year, to more than 33 billion francs, should make it possible, according to the minister of universities, for French research to become better integrated in the economic life of the country, thanks to a simplification of its functioning and a diversification of its actions.

Statement of Minister of Universities

Paris AFP SCIENCES in French 13 Sep 79 pp 2, 3

/Text/ A meeting of the Council of Ministers devoted to science and technology, chaired by Mr Valery Giscard d'Estaing, included notably a presentation by the minister of universities--Mrs Alice Saunie-Seite--explaining the new orientation of the CNRS.

Here is the text of the communique of the minister of universities on the new organization of the CNRS, which was the subject of three decrees published on 12 September:

"The CNRS, with its 8,300 researchers, its 13,660 technical and administrative engineers, its 1,400 research units, constitutes one of the most important scientific organizations in the world. Its new structure and working rules will permit it to contribute, in a manner that is better oriented and coordinated, more open to applications, and with more flexibility, to the national policy of scientific and technological development.

"The new texts clarify the role of the organs of direction. The president of the center and the council of 15 members, of whom 8 are scientific personalities, will define the broad lines of orientation and priorities, and will determine its budget.

"Under their authority, the general director will see to the execution of this policy, with the assistance of the committee of direction, the scientific committee, and the consultative committee on personnel.

"The wider scientific community remains actively associated in the discussion and evaluation of the results of the work of researchers through the medium of the national committee, two-thirds of whose members are elected, and by its majority representation in the scientific committee.

"The texts do away with the present duality of the powers, split between a general director and an administrative and financial director. In order to lighten the administrative responsibilities of the researchers, there is a lessening of concentration (a postiori verification, appointment of secondary computers and accountants, simplifcation of the budgets).

"The government has entrusted the presidency of the CNRS to Mr Charles-Georges Thibault, research director of the National Institute of Agronomy, world renowned for his works on the physiology of reproduction."

9347
CSO: 3102

CURRENT SOLAR ENERGY DEVELOPMENT, TECHNOLOGY

Plans of Solar Energy Commission

Paris L'INDUSTRIE DU PETROLE in French Jan 79 pp 4-8

[Article by Nicole Dupont: "Solar Energy in France: Much Remains To Be Done"]

[Text] The benefits France can derive from solar energy are twofold. The first is the use of such energy within the national territory, and the second is the export of solar-related equipment and technology.

At the national level, h[illegible] is being placed in biomass energy, which may furnish the equivalent of 12 million tons of petroleum in the year 2000, and in solar water heaters and heating plants.

COMES [Solar Energy Commission] works towards popularizing such systems in France and reducing their added costs by providing subsidies to water-heater purchasers and by establishing a structure capable of informing and advising consumers.

COMES encourages and subsidizes research on the main exportable technologies -- solar powerplants and photovoltaic cells -- as well as experiments of various solar energy applications in the overseas territories and departments.

The Solar Energy Commission was officially set up a little over a year ago, on 22 February 1978. Its president, Henry Durand,[1] formerly general director of the LEP (Applied Physics and Electronics Laboratory) was not to be appointed until 15 March 1978. The first meeting of the board of directors of COMES took place on 20 June 1978 and the Commission could not occupy its headquarters until the last quarter of the year. At the present time, there are some 30 persons involved, a very small number for an organization whose tasks include coordinating the action of the different public and private organizations involved in solar energy, working out an overall French policy in the field, promoting research and the use of solar energy by manufacturers and private interests and ensuring compliance with international cooperation agreements made concerning solar energy.

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1 See interview with H. Durand: L'INDUSTRIE DU PETROLE, No 496, Special Energies 1978.

For the time being, Durand may call upon foreign experts if necessary and he hopes that next year, his request for the creation of an additional 20 posts will be accepted. Only now can one glimpse the main lines of the role which COMES intends to play.

Forestry Development

Although the smallest portion of the national solar budget was granted to the upgrading of agricultural and forestry products this year (15 out of a total of 276 million francs), the government nevertheless places great hope in this domain.

Out of the equivalent of 17 million tons of petroleum (5 percent of all anticipated energy consumption) that could be supplied by solar energy by the year 2000, the equivalent of 7 million tons would come from a more systematic use of wood as a fuel and another 5 million tons could be supplied by specific crops or the recovery of plant waste.

In France, only 60 percent of the forests are worked, while the figures are 80 percent for the Federal Republic of Germany and 90 percent for the Scandinavian countries. Only 30 million cubic meters out of a total potential production of 50 million cubic meters are harvested. And yet, wood could be competitive even now. For example, wood for use in paper mills costs 120 francs per cubic meter and 7 cubic meters (840 francs) constitute the equivalent of 1 ton of petroleum, while 1 ton of petroleum costs over 1,000 francs. One can therefore imagine how much oil could be saved by using the 10 million cubic meters of woods not now worked, the 5 million cubic meters of plant and mill waste that are left to rot.

According to the minister of industry, this operation could supply 20,000 jobs between now and 1985 and it would also rehabilitate French forests. Naturally, the problem is not that simple: A rational use must still be found for the wood.

Three possibilities are being considered: heating by simple burning in individual or collective furnaces located near forest zones and serving homes or small industries; the combined production of heat and driving power that could be used for urban heating and be connected to the EDF [French Electric [Power] Company] system; and finally, distillation making it possible to produce methanol, acetic acid and formic acid, the point of departure for synthetic chemistry and coal.

One can also anticipate the cultivation of high energy yield plants or plants from which high energy composts could be derived. Futuristic research which, according to Giraud, could yield results in the coming decades is seeking to make the most of certain bacterias containing enzymes capable of transforming hydrogen and looks to the future use of the separation of electric charges induced by light in order to obtain biological photovoltaic cells.

For the purpose of coordinating and promoting research and its applications in the field, a bioenergy committee has just been set up under the aegis of COMES and the general director of the National Institute of Agronomic Research (INRA) will be a member of the COMES board of directors.[1]

Thermodynamics: 42 Percent of Budget

While biomass energy, which by the year 2000 should supply most of France's energy, absorbs only 5 percent of the COMES budget, research on thermodynamics represents 42 percent. This may seem paradoxical at first when we already know that the thermodynamic powerplants will undoubtedly be poorly adapted to the French climate even if they do one day yield conclusive results. However, one must not forget that the French solar program has two economic objectives: The first is to make it possible to cover part of France's energy needs and the second is to encourage the establishment of an industry which, by means of its exports, could help to balance payments. In this sense, thermodynamics could have a role to play.

"France owes it to itself to have a research policy in the field of solar energy," Durand tells thermodynamics critics. "The big telescope we are financing in Hawaii for a third party costs as much and no one talks about it because everyone thinks that France deserves to have a telescope," he recalls, going on to add that Themis should not be considered as a powerplant capable of competing in France with the nuclear or fuel powerplants, but as "a testing bench, a research tool."

Whatever the case, Durand does not intend in the future to expand the thermodynamics package he inherited from the DGRST [General Delegation for Scientific and Technical Research]. The most costly project, Themis, will amount to 80 million francs (nearly 100 million according to the EDF). Since the 1978 and 1979 fiscal years have already been committed, 1980 and 1981 remain, with 1981 being quite light.

"From the standpoint of financing, there is still one hard year ahead," Durand says. "After that, funds will be able to be released for other things. For example, in the field of biomass energy, our program will develop very quickly."

Calls for bids for Themis, the powerplant with 2-megawatt towers, were issued at the beginning of January and work at the site should begin in the spring at Targassonne. The first tests could take place in the spring of 1981.

The Bertin-AEC powerplant, whose construction should be completed in Corsica next year, will be much less expensive: 20 million francs. However, its power will only be 300 kilowatts.

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[1] On the subject of bioenergy, one should note the excellent work by Roger Dumon: "La Foret, Source d'Energie et d'Activites Nouvelles," published by Masson.

France is also to supply one-sixth of the financing for a 1-megawatt European powerplant that should be finished by the end of next year and whose total cost will be 9 million accounting units.

As for Them 2, the "advanced" version of Themis, it is still in the design phase and COMES devotes only 1 to 1.5 million francs to it a year.

In the future, one can expect a second generation of mixed solar machines which will also operate with makeup fuel, which would give them a yield of 30 percent instead of 18 percent.

French Solar Budget (in millions of francs)

	Housing	Thermo-dynamics	Photovoltaic cells	Biomass energy	Miscellaneous
COMES	14	42	24	5	15
Other	55	43	58	10	9
Total	69	85	82	15	24

Photovoltaic Cells

Photovoltaic cells should make up only a very small percentage of French solar energy by the year 2000. However, they have the merit of simplicity of use and despite their high cost, are already preferable in isolated places where it would be necessary to install electric lines over long distances even though the need for electricity is very small.

COMES therefore increased research and development subsidies from 6.5 million francs in 1977 to 9 million francs in 1978. Some 60 percent of these sums were granted to industry. Moreover, the SAHEL program of the Ministry of Cooperation devoted an average of 3 million francs yearly in 1977 and 1978 to photovoltaic demonstration operations in Africa.

Furthermore, a guarantee of purchases for producers and an increase in production could bring prices down.

In 1978, COMES devoted 5 million francs to the purchase of photovoltaic cells with a total power of 55 kilowatts, nearly a third of all RTC [expansion unknown] production. These cells are being used in the overseas departments and territories by the Ministry of Cooperation, the AEC, French television broadcasting for its low-power relay transmitters and the army.

Certain measures have been taken to stimulate the market: It will be the task of an interministerial group to study the establishment of photovoltaic stations whenever possible. Action in overseas departments and territories and in countries receiving financing from the Aid and Cooperation Fund (FAC) will be stepped up. Finally, in embassies, consulates and cultural centers abroad, there will be demonstrations, using simple and concrete applications, of French photovoltaic techniques.

Action in Overseas Departments and Territories

The overseas departments and territories have everything they need to make them the promised land of solar demonstrations. Generally speaking, they have ample sunshine and there are many isolated areas requiring little electricity.

An initial program was begun in Polynesia in 1978 based on "concerted solar action," co-financed by COMES, the AEC and the territories. A total of 12 million francs will be spent between 1977 and 1980 on a dozen projects using varied technologies (photovoltaic cells, thermal and aeolian energy). One should also note the study of sites in the "thermal energy of the seas" program co-financed by COMES and the CNEXO [National Center for Exploitation of the Oceans] (6 million francs in public funds and 4 million francs in private funds over 3 years), mainly being carried out in Polynesia.

COMES now wants to look to the other overseas departments and territories. A delegation is to be sent to New Caledonia, where COMES has already subsidized -- usually at a rate of 50 percent -- several facilities using photovoltaic energy. Preliminary studies have been made on the use of the potential aeolian energy of the Kerguelen Islands. A mission from the Delegation for New Energies went to the Antilles in mid 1978. A market study has just been completed by the BRGM [Bureau of Geological and Mining Exploration]. The main short-term outlet would be hot water for homes and a solar energy water heater assembly plant could be set up locally. Photovoltaic cells could be used at volcano observation stations and a study will be made of the use of sugar cane plant waste.

Consideration is also being given to the construction of a solar energy water heater plant in Reunion, to be financed by local capital with aid from the government.

Finally, COMES is to begin a study of the use of biomass energy in Guyana.

Solar Energy in Housing

Outside of biomass energy, in France, only the use of solar energy in housing can be profitable in medium-range terms. Furthermore, in order for it to become more widespread, prices must become more competitive and the public must be made aware of the problem.

Several types of action have been or will be undertaken to overcome the handicap of the current cost of solar energy. The most widely known is undoubtedly the "1,000-franc bonus" granted to any private person acquiring a solar water heater approved by COMES and helping to reduce the added cost of the equipment. This bonus was criticized somewhat by water heater manufacturers who think that it could have been better used to aid builders directly. The latter do in fact complain of having to bear the cost of laboratory testing needed for approval. The implementation of the bonus

(ministerial order of 6 April 1978) took rather long and it was not until October and November that the credits were released. A year later than Colli had predicted, solar water heaters are beginning to gain ground, somewhat timidly, it is true. According to Durand's figures, the total area of captors produced in France in 1978 was reportedly from 30,000 to 35,000 square meters, when this year it should be 70,000 square meters, with 20,000 square meters for water heaters alone. The 1,000-franc bonus will be extended for the first quarter of 1979, but the government is considering other means of support for the future, particularly as regards industry.

As another incentive measure, additional loans of 3,000 francs for collective housing units and 4,000 francs for individual housing units will be granted to welfare project foremen in the case of new financing aided by the government (PLA, subsidized rental loan, and PAP, home ownership loan).

On the other hand, tax incentives could be more effective than they now are. At the present time, every taxpayer can deduce from his declaration 7,000 francs plus 1,000 francs in interest on loans per dependent for all expenditures incurred to insulate the home, plaster, modernize the furnace or acquire solar heating equipment. Since this last item often comes after the others, it is rarely used as a tax deduction. The only positive point is that this year, one will be able to carry over from one year's declaration to the next any deductions relating to expenditures for solar equipment or energy conservation.

Nevertheless, France is still far behind the American or German policy: the granting of a tax credit (and not a reduction in the tax base) equivalent to 25 percent of the investment, with a ceiling of $2,400 for 10 years in the United States and 12,000 marks for 5 years in the Federal Republic of Germany.

Information on Solar Energy

Concerning the establishment of a system to aid builders, COMES is confronted with the problem of choosing the enterprises to be the beneficiaries. On the occasion of the individual solar water heater contest launched in 1977 by the Ministry of Environment and the low-cost housing program, 78 candidacies were proposed and only 6 were retained. None of the 6 was perfect.

Durand believes that on the French solar water heater market, there is room for only four or five enterprises and he believes that one will soon witness the emergence of a few builders among which he would like to see only the large firms. How will the selection be made? It will most likely be through a natural process of the withdrawal of the weaker and the less competent. An initial group will probably not gain COMES' approval or will not even seek to gain such approval for different reasons, mainly the cost of the tests. "If one cannot pay 14,000 francs to have a label guaranteeing quality to the consumer, then one will not go on the market," the president of COMES told us.

Quality control is naturally very important. There have already been complaints of defective or poorly installed solar equipment. The training of installers is in fact of prime importance and the older companies with a coordinated staff of installers who can be easily trained for solar energy equipment have an advantage. Information to the consumer is also important. A given water heater that is less expensive than one without an exchanger may operate perfectly well in a region where it does not freeze and where hard water does not risk scaling it, but the consumer must be informed. For this purpose, Durand anticipates subsidizing competent consulting firms on the local level for 1 or 2 years. This solution would present the advantage of "decentralizing" solar energy and enabling the public to become familiar with a new profession: that of being an expert on thermal problems and solar energy.

Professionals and the public must be taught to systematically include these problems in their thinking when planning to build. In France, people often build for 50 years and every new building must foresee the possibility of easily incorporating solar heating or solar water heating when -- perhaps in a dozen years -- such equipment is widespread.

Moreover, there must be a rediscovery of passive architecture in order to take into consideration the size of openings, the layout of housing in terms of climate, and so on. The Ministry of Environment and Living intends to publish a brochure soon entitled "building with the climate." Its purpose will be to make all builders and designers aware of the principles of bioclimatic architecture.

Demonstrations will become more widespread. Colli financed some 30 of these, spending on the order of 3 million francs per year. COMES is spending 5 million and this sum could increase to 7 or 8 million, which would make it possible to carry out from 50 to 100 operations yearly. This may seem to be a large figure but it represents only one demonstration operation per department every 2 years, which is perhaps too little to have a decisive effect.

Regional and local actions are going to be launched to make up for this insufficiency. A joint committee made up of persons from COMES and the local community will have to manage funds supplied by both parties and aimed at subsidizing pilot operations. An initial sorting of applications for subsidies will be carried out at the local level.

The operations envisaged may include not only new buildings, but old buildings as well. They will involve such things as expanding the practice of preheating water for homes before completing the process by using fuel, gas or electricity in order to save on precious energy.

By limiting these contracts with local communities to about a dozen, COMES hopes to have a more tangible effect on the regional level. This does not mean that other cities or communities will not be able to receive subsidies

because it is to be hoped that good demonstrations are not the monopoly of any region of France.

Opportunities at Home, Abroad

Paris L'INDUSTRIE DU PETROLE in French Jan 79 pp 17-21

[Article by Nicole Dupont: "Applications of Solar Energy"]

[Text] At the present moment, the only marketable applications of solar energy in France are water heaters and, to a lesser degree, heating plants. Solar water heaters are not yet in wide use due in part to the added cost they represent, and also due to a lack of aggressiveness on the part of manufacturers, which are either small companies of insufficient size to undertake effective marketing measures or larger firms that view solar energy as simply a diversification of their activities and have therefore not launched themselves into it completely.

Solar heating plants are also hindered by the high costs involved and a lack of reasonable and competent specialists.

Photovoltaic cells are mostly export-oriented for applications in isolated areas where they represent the ideal solution for producing electricity. Their cost is still excessive, but higher rates of production should lower their price in the forthcoming years.

There is little future for solar powerplants in France, but they do have possibilities abroad if the obstacle of their cost and sophisticated technology can be overcome.

France is in an especially good position on the African markets. In Asia and Latin America, it is obliged to deal with Japanese and American competition.

In recent months, there has been more and more talk of solar energy. Technical journals, home decorating and consumer periodicals all add their own comments, foreseeing, fairly realistically, a "solar" world or comparing the various types of equipment already on the market. Growing numbers of persons with varying degrees of means and enthusiasm are getting into solar energy, bringing together businessmen anxious to set up enterprises or diversify their activities, politicians seeking to create jobs and ecologists concerned with preserving the environment. In the face of this idyllic picture, one may well wonder whether solar energy truly offers a place for French manufacturers.

Water Heaters

No longer does Colli announce that 3 million solar water heaters will be installed in France by 1985. Nevertheless, the solar water heater does have a future in France. It is even the type of solar equipment best adapted to the little sunshine our country has. Purchasers may now expect to amortize

a water heater in 12 to 15 years (6 to 7 if they are lucky enough to live in the Midi), after which they will be able to have free showers and enjoy the satisfaction of not causing any pollution (except for visual pollution, according to those whose sight is offended by the captors). However, it is highly likely that with time, these captors will be integrated into the architecture better and better and people will become accustomed to them. In the Netherlands, the first windmills were deemed to be so unaesthetic that painters omitted them from the landscapes in their paintings!

Japan produces 160,000 solar water heaters a year and already has 2 million installed. Israel produces from 30,000 to 40,000, many of which are exported. It is very difficult to evaluate French production and stock. According to Durand, president of COMES (Solar Energy Commission), France has no more than 6,000 to 7,000 units, 1,800 to 2,000 of which were reportedly installed last year. As for the captors (only part of whose production is used to equip water heaters), some 4,000 square meters were manufactured in 1975, 30,000 in 1977 (figures cited by Colli) and 30,000 to 35,000 in 1978. The estimate for 1979 is 70,000 square meters (according to Durand), with 20,000 square meters to be used for water heaters (which gives the equivalent of 10,000 individual water heaters if the premise is that each unit is usually equipped with a 2-m^2 captor). Other estimates are a production of 65,000 square meters for 1978 and 100,000 square meters for 1979. The German builder Stiebel Eltron even advances the figure of 300,000 square meters.

This quarrel over estimates is perhaps not very important, but it emphasizes France's lack of precise, uncontested figures and the danger that this situation may represent for manufacturers, who take a fairly "blind" plunge. In the United States, for example, President Carter ordered a survey of all public buildings that could be equipped with solar devices (not only water heaters). In France, when one builds a public building, it is now required to study the possibility of the eventual inclusion of such equipment. And yet, it would appear that this requirement is generally considered as a mere formality and leads to a negative response.

Could manufacturers not make their own estimates?

Here one is confronted with a problem arising out of the structure of the French solar water heater industry. On the one hand, there are the very small enterprises (nearly 100) which do not have the means to complete such a survey, and on the other hand, one has the large firms which view solar energy merely as a diversification of their main activities and which, before investing larger sums of money, are waiting to see the results obtained by their smaller brothers.

This situation is disturbing, all the more because the foreign builders (German and Israeli), which are stronger and perhaps more vigorous also, are well on the way to bringing the litigants together by establishing themselves on the French market in force.

Is there any way to avoid such an outcome? It is certain that an additional commercial effort on the part of all the enterprises, large and small, could only be beneficial. Moreover, for the small firms, one could envisage a joining of commercial efforts, particularly with respect to foreign prospecting. GESOL (Interunion Solar Energy Group), which brings together all the unions involved in solar equipment manufacturing, intends to participate in the Atlanta exposition in June and to put out a professional yearbook on that occasion, but it does not yet know whether it will manage to collect the funds needed to carry out this plan.

The builders are also asking for government aid (perhaps more substantial than the 1,000-franc bonus, whose terms should also be reviewed), in order to break the vicious circle that causes solar water heaters to be more expensive, partly because production is not sufficient, and production to be low because prices are too high and discourage consumers. Actually, even taking the 1,000-franc bonus into account, the added cost of a solar water heater is from 1,000 to 4,000 francs. After all, some builders think, we are also working in the general interest by reducing the French energy bill. This is a modest contribution but one that is nevertheless appreciable, for every solar water heater makes it possible to save the equivalent of .3 ton of petroleum per year, on the average. If France has 5 million solar water heaters by the year 2000, it will save the equivalent of 1.5 million tons of petroleum. It should be noted that for 1985, COMES' objective is 200,000 water heaters installed.

Another way to support the solar equipment market would be to grant special bank loans allowing buyers to decrease the length of amortization. The the problem of cost is not the only one to overcome, as we have seen. Solar captors still give rise to reticence and city planning departments sometimes discourage candidates.

Are there opportunities abroad for French solar water heaters? It would appear that among all the apparatuses using solar energy, the water heater is not in the best position for export. Naturally, it is a kind of equipment with a simple technology, but it is difficult to transport when not manufactured locally. Nevertheless, some companies are interested in the market. ELF [Gasoline and Lubricants Company of France] is developing a simplified solar water heater, without any thermosiphon and requiring very little maintenance. It would be particularly well adapted to tropical countries that do not always have qualified personnel capable of ensuring the installation and maintenance of sophisticated equipment.

Along the same line of ideas, ELF is also anticipating the production of solar stoves to be used in desert regions with a scarcity of fuel. Six or seven projects are being worked out and investigations must be completed in order to determine which type would be the most acceptable for the people in question. The difficulty resides in the rather high cost of the prototypes that must be build in order to complete the study. On the other hand, once mass production is begun, every unit should cost between 50 and 100 francs, an expense that could be borne by international organizations.

Solar Housing

There are two very different ways of heating one's home with solar energy. The first: passive architecture, does not require any special equipment. It simply consists of designing the building in such a way so that it will make the best possible use of solar energy. It does not necessarily imply an added cost compared with a less well designed house, and while it may not provide an outlet for material, it provides material for architects and thermal experts specializing in the field.

The second consists of active solar architecture. However, many obstacles oppose the development of this type of architecture. Investment costs are still high: 25,000 francs for new homes and in the best of cases, 80,000 francs for old units. Moreover, since heating is necessary in winter -- that is, during the period with the least sun -- the installation of captors means savings of not more than 40 to 50 percent. Considering the maintenance of the equipment, a user does not save over 1,000 francs per year on heating costs, whence an excessively long period of amortization (at least 15 years). Considerable progress could be made if it were possible to store heat from one season to the next. Nevertheless, there is no solution to this problem in the near future, especially since it is all the more difficult to store heat when the quantities involved are small, which is the case for individual housing units.

At COMES, it is estimated that if, by the year 2000, 5 percent of the old housing and 5 percent of the housing built since 1980 is equipped with solar heating, France will save the equivalent of 3 million tons of petroleum per year (it is estimated that by that time, there will be some 20 million homes in France).

While solar heating is not an excellent export possibility due to the difficulty in transporting captors and the fact that numerous countries such as the African nations do not always need heating, solar air conditioning and refrigeration can still constitute exportable products and technologies.

Photovoltaic Cells

The production of electricity by photovoltaic cells is undoubtedly the solar energy of the future. Simple and long-lasting, the cells produce electricity where they are and the electricity therefore does not have to be transported. They are especially suited to developing countries with a great deal of sunshine, where the population is scattered and the amount of electricity used very small. In France, they are still too expensive to compete with electricity produced by other means, except in very special cases: beacons, television relay stations, military uses, and so on. At the present time, a watt at peak times costs 70 francs in the United States, where it is hoped that the price will drop to 50¢ by 1986. This is perhaps a little optimistic. At any rate, it will be possible to reduce costs to $1.00 or $2.00 per watt by that time. In France, the second producer in the world after the United

States and ahead of Japan, a watt is a little more expensive at peak hours: 85 francs. There are two reasons for this: on the one hand, less intensive production, and on the other, a different policy.

Actually, RTC, a member of the Philips firm and up until this year, the only producer in France (where it employs a French technology), produces cells that are a little more expensive but longer lasting because they are encased between two glass plates. For their part, the Americans provide a guarantee, saying to themselves that when they have to replace their cells to honor the guarantee, the price of the cells will have dropped to such an extent that this will no longer pose any problem.

Whatever the case, producers are stepping up research in order to bring down the prices. While it is not possible to reduce the price of silica, the basic raw material used in the cells, 50 percent of the monocrystalline silicon bar is now lost when it is cut into slices and research is now being done in order to prevent this loss. Savings could also be achieved at the time of capsuling but an investment in machines would be necessary and this would only be possible with the development of production. Increasing the size of the cells would also help to reduce prices and there is now movement in that direction. Likewise, work is being done in order to process the silicon wafer by other means than by metal vacuum evaporation, which is very expensive, and consideration is being given to serigraphy. The monocrystalline plate will undoubtedly be valid for another 4 or 5 years, but it may give way to polycrystalline silicon spread on substrata. There is also some thought of resorting to the concentration of the sun's rays on the cell. However, this process would diminish one of its principal advantages: its simplicity.

In 1978, RTC produced 200 kilowatts and intends to produce double that amount this year. COMES buys 30 percent of its production in order to help it lower its prices and proceed to conduct tests and give demonstrations in France and abroad. This policy of purchasing production is identical to that of DOE [Department of Energy] in the United States. Some 90 to 95 percent of RTC's production is exported.

The first cells tried by RTC are still in operation and have been since 1961, at the University of Chile.

At the present time, one of the most interesting applications of the photovoltaic cells is undoubtedly the pumping of water in developing countries, particularly in Africa. Moreover, this formula presents the advantage of eliminating storage problems. The photovoltaic pumps, produced in France by Guinard, compete advantageously with diesel pumps up to a power of 2 kilowatts. By way of comparison, a 1,500-watt diesel pump costs from 8,000 to 11,000 francs, while a solar pump having the same power costs from 180,000 to 240,000 francs. However, the diesel pump does not withstand the tropical climate well and demands continuous maintenance, which is not the case of the photovoltaic pumps. At the present time, 25 Guinard pumps are being installed in Africa and the Middle East. The oldest ones were installed 3 years

ago and there have been no breakdowns. They were all financed by international aid. One must also mention the thermodynamic water pumps whose reputation no longer has to be established, as shown by the exceptional success of SOFRETES [French Society for Thermal and Solar Energy Studies], having completed 80 projects, with power ranging from 1 to 30 kilowatts, in some 20 countries.

Since the beginning of this year, RTC has no longer been the only producer of photovoltaic cells in France. A new company, France Photon, controlled by the American producer of Solarex photovoltaic cells and the French company Leroy Somer, has been set up in Angouleme and expects to produce 100 kilowatts beginning this year. For its part, Motorola has announced its intention of setting up a plant in Toulouse.

One is seeing more and more French-American agreements in the field of photovoltaic cells. In 1976, the CFP [French Petroleum Company] took over control of the American company Photon Power and the announcement has just been made of the establishment of a joint (50-50) subsidiary by the French firm Thomson and the American firm Exxon. This subsidiary, the Helioenergy Applications Company (SAHEL), will specialize in photovoltaic cells. More recently, Leroy Sommer purchased 15 percent of the Solarex Corporation (United States) stock and 20 percent of Solarex, Inc. (Switzerland), which uses the Solarex license in Europe and Africa. It increased its participation in France Photon, which it had previously controlled on an equal footing with Solarex, to 70 percent. Finally, the CGE [General Electric Company] and Sensor Technology have made an agreement in the same field. What is the reason for these accords? They naturally have to do with technological reasons, but it is obvious that the Americans are not unaware of the excellent contacts made by the French in Africa, a very promising market for solar energy. As for the world photovoltaic cell market, it is also very promising since it could amount to 70 megawatts by 1982.

In the more distant future, the Americans are thinking about launching a photovoltaic cell solar collector into space in 1990. It would be capable of producing 4,000 megawatts.

Solar Powerplants

Another means of producing solar electricity is the thermodynamic powerplants. In order to be competitive with nuclear electricity, between now and the year 2000, they would have to reduce their production costs ten times over, which is not impossible, but not easy either. They will never be able to attain the simplicity of use of the photovoltaic cells. Nor is it certain that they will be able to withstand the tropical climates and they will always require maintenance done by qualified personnel. In contrast, in order to compete with nuclear energy, photovoltaic cells would have to be 50 times less expensive and it is not absolutely certain that the objective will be reached by the year 2000.

Another aspect of the problem is that the poorest developing countries probably do not have the means to build solar powerplants, while the richer ones owe their wealth to oil and have a less urgent need to turn to solar energy. There are a few exceptions to the rule, however: Saudi Arabia, which has asked SOFRETES to build an electric powerplant with a capacity of 240 kilowatt-hours per day; Iran, which is interested in solar energy, but more for the purpose of air conditioning, refrigeration, pumping, water heating or the drying of crops; Nigeria; and above all, Egypt, which refuses to have more than two nuclear powerplants on its soil by the year 2000 and which would like to produce 2 gigawatts by solar energy, whence its interest in powerplants of the Themis type.[1] For countries with a scattered population, as is the case in Africa, huge powerplants of this type are not justified. On the other hand, small powerplants of the Pericles type[1] would have a good chance of finding a market.

One can therefore ask about the future opportunities awaiting the solar powerplants. Our climates are undoubtedly not sunny enough to enable them to have a sufficient output and it is not certain that the market that may open up in countries such as Egypt will make the operation profitable. Without giving any categorical answer to this question, one may nevertheless ask whether this type of powerplant is not likely to become an operation similar to the Concorde: a technological success unfortunately accompanied by commercial failure. If the solar powerplants do still enjoy their hour of glory in the year 2000, it is to be assumed that in the more distant future, by the year 2040, other techniques will take over to supply energy in large quantities: fusion, breeder reactors or solar satellites.

Finally, there is one factor that must never be lost sight of and that may bring into question any attempt to evaluate profitability: An increase in the price of oil may make some sources of energy that are not yet competitive competitive sooner than previously thought.

Export Possibilities

If one makes a rapid survey of countries in which France has the best chance of marketing its solar equipment, one will note that among the oil-producing nations, one must take special note of Egypt, Nigeria, Iran and Saudi Arabia, with the reservation that the latter has no great need of such equipment given its small population and its limited industrial development. Moreover, having huge oil reserves, it is not in any hurry and wants to engage in solar research itself, with the cooperation of the AEC.

In Latin America, France could make important agreements with Brazil immediately. It can also hope to intensify its activities in Mexico, a country that is becoming wealthy thanks to oil, moving toward stability and above all, anxious

[1] Concerning the Themis and Pericles powerplants, see L'INDUSTRIE DU PETROLE, No 496, Special Energies 1978, an article by Rodot.

to establish its independence vis-a-vis the United States. The other South American markets are more difficult to reach, dominated as they are by the United States. All commercial ventures made in Venezuela over a period of a year failed, to the benefit of American or Canadian manufacturers.

There is a similar problem in Asia, a continent the French do not know well and which is rather the territory of the Japanese and the Americans. Consequently, the privileged market of France essentially remains Africa.

ELF-Aquitaine Company

Paris L'INDUSTRIE DU PETROLE in French Jan 79 pp 23-27

[Article by Serge Bielikoff Snea, New Activities Directorate, head of the Solar Energy Department: "ELF and Solar Energy"]

[Text] With an eye to developing and diversifying its sources of energy, the ELF-Aquitaine Company has launched into the field of solar energy production and use. Efforts have been directed towards two main areas, the first of which is low-temperature thermodynamic conversion for heating and the production of hot water. This has led to the use of solar roofs and collectors in public and services buildings. The work has also included solar ponds, which serve to produce and store energy on a larger scale.

The second area is photovoltaic conversion, which is by far the major field due to its potential uses, and it is already used by ELF to meet some of its own needs, notably in Gabon. In addition, by combining the experience of a variety of specialists (Guinard Pumps, Wonder Batteries, ELF), the GEW [expansion unknown] Energies joint venture opens up broad research and application possibilities for the procedure ("mini" powerplants for lighting, water pumping, and so on) in the Middle East, Africa and Asia.

When, several years ago, ELF-Aquitaine plunged into action aimed at developing sources of energy other than oil and natural gas -- particularly geothermal and solar energy -- it was responding to a triple concern: as a major national power company, helping to get these new sources of energy moving through an effort in scientific and technical research and development, exemplary demonstrations and the preparation of industrial developments in the field; using the knowledge of its teams and those of affiliated companies specializing in the production, distribution and use of heat, the design, manufacture and marketing of materials and equipment for heating and housing, while seeking out the best possible marriages between traditional fuels and equipment and new energy techniques; for the development of these techniques, cooperating with a certain number of foreign countries in which the firm is involved in oil exploration and production and, in certain cases, has already made use of solar energy to solve special problems of supplying energy.

The two privileged sectors of solar development in which the ELF-Aquitaine firm has worked are: low-temperature thermodynamic conversion for the

production of hot water and for heating; and photovoltaic conversion for pumping water and supplying small amounts of electric power, mainly in developing countries.

Low-Temperature Thermal Operations

Startup

Recent years have been marked by an increase in the number -- in response to governmental urging -- of experimental and demonstration facilities for the production of hot water for homes and heating, mainly for public buildings (hospitals and schools), individual and collective residences and commercial and recreational complexes.

ELF-Aquitaine has been associated with several of these facilities, participating in studies and engineering and, in connection with certain outstanding operations, by contributing to their completion financially: supplying hot water to and heating buildings on the campus of the National School of Industrial Techniques and Mining in Ales; supplying hot water to the Montpellier University Hospitals; heating the Boulou garage; supplying hot water to the old people's home in Perpignan; providing showers for the Montoberou camping sites; heating the Carbonne nursery school; and the villa in Corsica.

A campaign to inform the public was simultaneously waged, particularly through the setting up of solar pumps and heating equipment and air conditioning by means of solar heating pumps at some ten ELF service stations. A caravan equipped with solar materials for the production of hot water and electricity and an audio-visual program on new types of energy completed this information and awareness program aimed at the Languedoc Roussillon vacationers.

This period of apprenticeship made it possible to detect the equipment's weak points and strong points and in particular, led to the discovery that the solar captors previously available were not necessarily adapted to all the purposes for which they were being used. Naturally, their thermal performance was quite acceptable but their cost was high, and insofar as their use in housing was concerned, it remained very difficult to incorporate them into the architecture. These were two major obstacles to wide-ranging development of these applications.

ELF Aquitaine's Search for New Solutions

The ELF-Aquitaine Research Center teams therefore gave priority to a reduction in costs, reliability and ease of application by: 1) making a maximum effort to limit additions of specifically solar equipment by using customary construction structures so as to add the solar function to their usual function; and 2) defining solar equipment in terms of building standards and designing modular elements that could be put into the hands of professional builders or hot water and heating equipment installers, giving them the time to assemble them with additional materials of their choosing.

Ventilated Solar Roofing

This procedure, developed by the Siplast Company and ELF-Aquitaine, consists of recovering a large share of the solar heat received by a conventional type of industrial composite roofing comprised of a carrier element covered with thermal insulation. The roofing would be superficially watertight. The heat could be directed toward the inside of the building in the winter so as to reduce heating expenses or toward the outside in summer in order to lower the temperature and save on energy needed to cool the air.

The insulation-watertight layer complex is used as a solar absorbent whose calories are transmitted from the air circulating in the pipes, upon contact with the watertight layer.

This procedure does not modify the exterior aspect of the roofing.

It is a solar procedure without storage, but it also has an insulation function acting to save on energy. The calories recovered directly reduce spending on makeup heating provided by a fuel or gas hot air generator.

In addition to the fact that the look of the building is not changed, the major interest of the procedure resides in the low added cost as the result of the absence of specifically solar components to be included.

Conversion yields are lower than those of the traditional solar captors, which requires the use of larger catchment surfaces and limits the use of the procedure to buildings with large roofing areas: industrial warehouses, multipurpose rooms, and so on.

This technique is now being used to heat a plant in the Rhone-Alpes region.

Modular Hot Water Solar Captor

The Akuba Company and ELF-Aquitaine have developed a set of aluminum solar devices making it possible, in new buildings under construction, to provide an interesting architectural response for apartment buildings by including the captors in panels on the walls or in the roofing.

In both cases, the solar captors play a double role: solar conversion and construction elements. Depreciation caused by elements of construction, which the solar captors replace, reduce the added solar cost. Available in modular elements of all lengths up to 6 meters, these solar sections enable architects to choose the solutions best adapted to their projects.

In addition to this form of use in residential, collective and tertiary sectors, the ELF-Akuba modular captor can be used for the production of hot water in individual dwellings. That is how the Akuba 200 individual solar water heater is now being marketed and, in cooperation with Chaffoteaux and Maury, various other water heaters are being developed (for semi-industrial individual constructions, all housing with connections to fuel boilers, and so on).

Solar Pan

More futuristic in nature, the experiment being carried out for the past 2 years by the National Center for Ocean Development and ELF-Aquitaine on a solar basin with salt stratifications is aimed at capturing solar energy over large areas (one or several hectares) and storing it for long periods of time.

The solar basin is a shallow (about 1 meter) stretch of water that would capture solar energy on the bottom, where thermal insulation is ensured by blocking convection movements by means of a concentrated salt gradient. Such basins, the study of which was begun in Israel as early as 10 years ago and recently taken up by a number of American university laboratories, will be able to be used as a solar powerplant producing calories or energy and will require no modification in housing. With an area of 1,000 square meters, the Palavasles-Flots experimental basin is the largest built to date and the first in Europe.

Naturally, the price of the thermal unit delivered by the solar basins will determine the immediate economic interest and the time within which the technique can be used, whether it be in France or abroad, particularly in the Mediterranean countries and the Third World.

Solar Electricity in Developing Countries

With photovoltaic conversion, we take up a field of cardinal importance due to its fabulous potential for application when the cost of photovoltaic cells has dropped thanks to research and development work now being done on the international level.

However, there are already interesting land applications for the supplying of small amounts of power to isolated areas: either because these applications are competitive costwise with long-lasting chemical cells; or because of the service rendered, such as the current development of water pumping in areas where the use of traditional mechanical means is not possible.

As early as 1972, ELF-Aquitaine became interested in this technique in order to meet its own needs to supply electricity under the exceptional circumstances involved in oil production. For example, the setting up of photovoltaic generators on ocean platforms in Gabon, under difficult environmental conditions, led to very satisfactory operation of ELF-Gabon's security radiotelephone system. The cost of maintaining the system dropped to an insignificant amount and reliability was considerably improved compared with the different types of electrical supply previously used. These good results led to the setting up of some 50 ocean marker lights in Cameroon and ELF-Serepca is putting up radio retransmitters fed by photocells on Mount Cameroon. In Tunisia, microwave relay equipment is being set up, and so on.

GEW Group With Guinard Pumps and Wonder Cells

This knowledge in the field of supplying small amounts of electric power by photovoltaic systems will henceforth be of greater value outside the group with the establishment of an economic interest group -- GEW Energies -- which brings together Guinard Pumps, a world specialist in pumping and a leader in the development of electric pumps supplied by photovoltaic cells, Wonder Cells, the second-largest builder of cells in the Common Market and a specialist in photovoltaic generators, and ELF-Aquitaine.

It is the task of GEW Energies to review studies of water and energy needs in rural areas, design the necessary equipment to meet these needs and, using the means of each of the partners, build the necessary equipment: radiotelephony; microwave relays; educational television receivers; television relay transmitters; radio beacons; marker lights; railroad signals and controls; village mini powerplants for lighting, medical refrigeration, and so on; and pumps to supply water to villagers, livestock and market garden crops. This last technique is now giving rise to numerous applications: The simplicity of the Alta-X photovoltaic centrifugal electric pumps developed by Guinard and the possibility of limiting maintenance to a single annual visit have caused several countries to set up this equipment, despite the still high cost, in areas where the use of diesel pumps would have been impossible. This has made it possible to develop local resources: mini irrigation of market garden crops; irrigation of the dah [translation unknown] and the processing of fiber; and an increased livestock raising yield.

In connection with this development, in addition to the geographical complementarity of the commercial means of the GEW partners, the pooling of the knowledge of each one, particularly the knowledge of the behavior of photovoltaic cells under highly diversified environmental conditions, ensures better chances for the startup of these photovoltaic applications, which, within a few years and when costs have been reduced, should experience exceptional development in Africa, the Middle East and Latin America.

In order to prepare for such a future, ELF-Aquitaine is now stepping up its efforts and going beyond the initial isolated experiments, embarking upon village or regional projects in cooperation with national and international organizations responsible for development in these geographical areas.

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THEORY, METHODS OF COPRODUCTION OF POWER DISCUSSED

Paris L'INDUSTRIE DU PETROLE in French No 504 Mar 79 pp 39-43

[Article by A. Le Fur, engineer]

[Text] Main industrial energy needs are satisfied by means of electricity and heat, two forms of energy which in most cases are produced separately with low overall efficiency. Electricity, moreover, can only be generated at the expense of substantial losses, as two-thirds of the intitial energy is dissipated in the environment. This fact has given rise to the well-known, yet largely unapplied idea (at least in France) of producing both forms of energy through a single system, which recovers dead losses. Such a concept, referred to as cogeneration, is one of the most economical means of utilizing primary energy sources. While various systems, all economical, can be used to achieve cogeneration, one in particular merits special attention: a gas turbine associated with a heat recovery boiler. Today such an installation is simple, requires limited space and can readily complement conventional facilities. Providing long-duration nominal service is insured, a cogeneration system is economically justifiable at the 1 MW capacity level.

The historical event of 19 December, the realization by industrialists of their dependence on electricity and certain recent proposals of the minister of industry have brought back into prominence a vocabulary, the terms of which have been known for a long time: autonomous production, heat-power, power-heat, total energy.

In fact, for the industrialists this abundance of terms translates only one reality: that of acquiring as economically as possible a minimum of self-sufficiency in satisfying their electric energy needs.

For clarity, we will use:

--the term autonomous production for equipments that produce only electric energy (conventional electric generating set),

--the term heat-power for equipments intended for the production of heat. Electric energy is generated only in the process of fulfilling thermal needs (back pressure turbine system),

--the term power-heat for equipments intended for the production of electric energy. Thermal energy is produced here only in the process of fulfilling electricity needs (motors and gas turbines with recovery),

--the term total energy for equipment permitting the fulfillment of all the energy needs of a group of consumers (electricty, heat and cold without any other fuel contribution).

Such a precise definition of total energy limits its field of application. It seems to us that it is not economically and technically desirable to create installations which are totally independent of the EDF [French Electric Company] system.

In addition, purely autonomous production (except maybe from gasification of vegetable wastes) has practically no interest: it is more costly and does not entail any gain in primary energy. This leaves power-heat and heat-power, which we will regroup under the term "cogeneration," that is, combined production of thermal and electric energy.

This double generation of energies is quite easily implemented today--with some safety measures, nevertheless--and is economically justified once long-term utilization can be planned. In addition, it produces significant conservation of primary energy as we will try to prove.

Characteristics of Systems Consuming Energy

Industrial activities generally consume energy in two forms which, in the traditional concept, are produced separately:

--thermal energy (Q) in a boiler room where the essential parameter is the efficiency of combustion, generally around 0.85. That is, 1.18 kWh of fuel must be consumed in order to obtain 1 kWh of thermal energy,

--electric energy (E) in hydraulic, thermal or nuclear powerplants. Today thermal generation still remains preponderant in France.[1] Electric production is customarily estimated on the basis of 2.9 kWh of fuel for 1 kWh of delivered electricity. Moreover, that means that the generated output is 0.34. Thus, the overall efficiency of separately produced energy can be represented by:

$$\eta_G = \frac{E + Q}{C} = \frac{E + Q}{1.18\ Q + 2.9\ E}\ .$$

1. In 1977, 202 TWh of electric energy were produced as follows: hydraulic, 37.5%; thermal, 54.1%; nuclear, 8.4%.

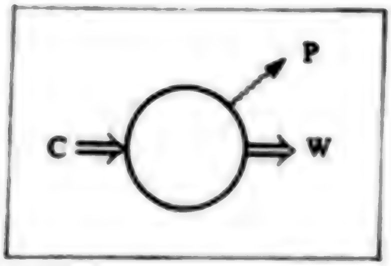
Or, using the ratio of the two forms of energy $k=\frac{Q}{E}$ as the only variable:

$$\eta G = \frac{1 + k}{1.18 + 2.9} .$$

Why Cogeneration?

Generation of electric energy, outside of hydraulic generation, is achieved by means of a thermal engine that functions according to thermodynamic laws. That is, it describes a thermodynamic [heat] cycle between two temperatures: the heat source T and a lower temperature sink T_0. The mechanical power obtained results from transferring an amount of heat from one to the other and, in order to maintain the level of T_0, this amount of heat must be discharged. From the point of view of production of mechanical energy (later transformed by the alternator into electric energy), it must be considered lost.

This thermal engine can be represented by the diagram:

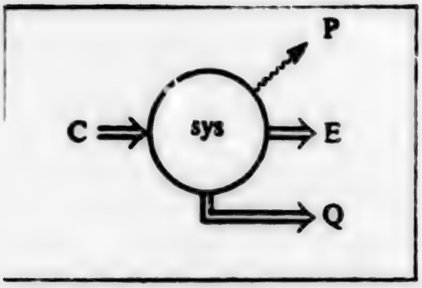


C = fuel
W = mechanical energy
P = loss to the lower temperature sink

and its capacity for producing mechanical energy (and thus, electric energy) by the efficiency of its cycle $\eta_c = \frac{W}{C}$.

Obviously, it is tempting to catch the heat discharged from the lower temperature sink to satisfy thermal needs, when these are concomittant to the electric needs. In this way, by definition, a system of cogeneration is achieved. It is quite obvious that in these systems no electric energy is produced unless its thermal counterpart can be utilized and, inversely, no thermal energy recovered unless electric energy can be consumed.

The representative diagram of the system becomes then:



and its capacity for cogeneration is characterized by:

--its efficiency cycle: $\eta c = \frac{E}{C}$;

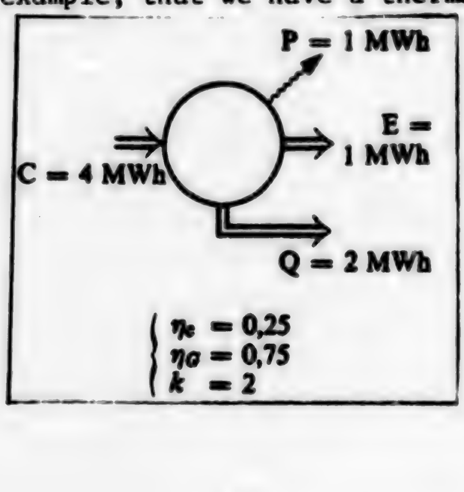
--its overall efficiency: $\eta G = \frac{Q + E}{C}$;

--its energy ratio: $k = \frac{Q}{E}$.

Energy Interest in Cogeneration

The interest of cogeneration--from the point of view of energy consumption--comes from comparing its overall efficiency with that of energy produced separately for the same value of $\frac{Q}{E}$.

Let us suppose, for example, that we have a thermal machine with the following specific diagram:



For a concomitant energy demand E and Q (in the ratio $\frac{Q}{E} = 2$) the primary energy consumed in separate generation is:

$$C_o = (Q + E) = Q + E$$
$$\frac{1.18\ k = 2.9}{1 + k} = \frac{Q + E}{0.57}\ .$$

While in order to furnish the same quantities of energy the cogenerating system would consume:

$$C = \frac{Q + E}{\eta G} = \frac{Q + E}{0.75}\ .$$

The coefficient of energy gain is immediate:

$$\frac{C_o}{C} = \frac{0.75}{0.57} = 1.31.$$

Of course, energy gain is not sufficient criteria. Still, taking into account the respective prices of thermal energy, electric energy and fuel, there must be enough gain to offset in an acceptable time the added investment.

Also, the formulation of energy gain can be clarified:

$$G_E = \frac{\text{fuel for separate generation}}{\text{fuel for cogeneration}}$$

$$G_E = \frac{1.18\ Q + 2.9\ E}{\frac{Q + E}{\eta G}} = \eta G\ \frac{1.18\ k = 2.9}{k = 1}$$

The variations of G_E in function of ηG and k are shown in the following table.

k / ηG	1	2	3	4	5	6	7	8	9
	2,04	1,75	1,61	1,52	1,47	1,43	1,40	1,37	1,35
0,5	1,02	0,88	0,81	0,76	0,74	0,72	0,70	0,69	0,68
0,55	1,11	0,96	0,89	0,84	0,81	0,79	0,77	0,75	0,74
0,60	1,22	1,05	0,97	0,91	0,88	0,86	0,84	0,82	0,81
0,65	1,33	1,14	1,05	0,99	0,96	0,93	0,91	0,89	0,88
0,70	1,43	1,23	1,13	1,06	1,03	1,00	0,98	0,96	0,95
0,75	1,53	1,31	1,21	1,14	1,10	1,07	1,05	1,03	1,01
0,80	1,63	1,40	1,29	1,22	1,18	1,14	1,12	1,10	1,08
0,85	1,73	1,49	1,37	1,29	1,25	1,22	1,19	1,16	1,15
0,90	1,84	1,50	1,45	1,37	1,32	1,29	1,26	1,23	1,22

It demonstrates that overall efficiency should not be taken into consideration alone. A system with overall efficiency of only 0.75 but a value of k = 2 must be preferred to a system with a significant overall coefficient (for example 0.85), but also a higher value of k (for example 5).

Choice of Equipment for Cogeneration

Cogeneration can be achieved today with 3 types of equipment:

--high pressure boiler + steam turbine + utilization

--gas turbine + waste heat boiler

--alternator + waste heat boiler.

Cogeneration with Steam Turbine

Obviously, we are talking of a back pressure turbine whose discharge feeds a system of steam distribution or a feedwater heater.

This type of equipment is generally characterized by a very large value of the coefficient k, the ratio of thermal energy to electric energy produced.

For example, with steam at 40 bar, 400°C and a back pressure of 5 bar, k = 6.

And in the industries where steam at 5 bar is used as the thermal energy vector, the ratio of thermal needs to electric needs rarely exceeds 5. This ratio becomes lower through the years since demand for electricity increases faster than demand for thermal energy.

The result is, in many cases, that the steam turbine becomes inadequate to satisfy industrial energy needs.

Cogeneration with Alternator

We must distinguish between two types of alternators:

--Diesel engines using domestic fuel oil as hydrocarbon,

--gas engines, which are diesels adapted to the use of gas.

The former have no interest from the point of view of cogeneration since they use a fuel which is costly and even with heat recovery the kWh produced is too expensive.

The latter, however, are interesting since their efficiency is high (33%) and the price of the fuel used can, in certain cases, be compared with the price of ordinary heavy fuel [oil].

These characteristics lead to a very low ratio $\frac{Q}{E}$ while maintaining a high level of total efficiency, and thus, a very good theoretical potential for

cogeneration. They are interesting from the point of view of energy conservation, but these alternators are costly to maintain.

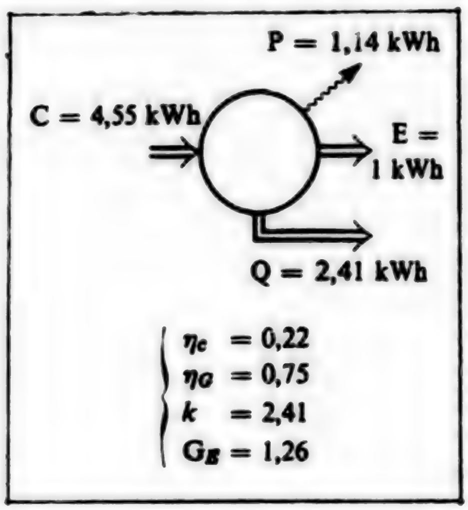
In addition, the thermal energy is available at two levels: one low-temperature level (80%) to cool the engine, and a high-temperature level for the discharged gasses. This complicates recovery and practically makes it necessary to have a low-temperature sink (cooling by evaporation or heat exchange).

Cogeneration with Gas Turbine

The essential interest of gas turbines lies in the fact that they are rotating machines which, associated with a waste heat boiler, present energy cogeneration diagrams quite similar to those of alternators, without the inconveniences.

In fact, their maintenance cost is minimal--at least during the first 5 years--, thermal energy is recoverable from the only gasses discharged, that is, at only one level and the only low temperature sink used is the atmosphere.

The potential of gas turbines becomes evident using the diagram of cogeneration and its characteristics:



Conclusions

Analysis of the cogeneration diagrams show that gas turbines can be adapted very well to satisfy thermal and electric energy needs of industrial consumers. This is due essentially to the small value of the ratio $\frac{Q}{E}$ which makes it possible to produce much more electric energy for a given thermal demand than any other solution.

Of course, it is in no case a matter of producing more electricity than is needed since the sale of energy to EDF--under present conditions--is not sufficiently attractive.

For a demand having a significat value of $\frac{Q}{E}$, it is desirable to limit the thermal energy cogenerated to that available through the generation of needed electricity. To satisfy the complementary demands traditional boilers would be more efficient and should be used.

The costs of investing in these equipments is such that they can only be used for basic output. And in order to choose appropriate equipment, a serious analysis must be made of thermal and electric consumption histograms.

The size of the equipment must be considered as much as the type. It can be said in conclusion that the best equipment is one which will make it possible to meet the maximum of electric needs with the lowest value of the ratio of $\frac{Q}{E}$ to the output, the constraint at any time being $Ek < Q$.

That means simply that it is not the total efficiency which is important, but the efficiency of the ηc cycle, even when there is heat recovery.

The equipment available today makes it possible to plan for cogeneration, under favorable circumstances, when there is a demand for electricity of the order of 1 MW and a thermal demand near 3 MW.

The equipment requires limited space, partially replaces existing thermal equipment and is easily connected to the national system which would be therefore unburdened.

This is certainly one of the most efficient methods of participating in the national effort to conserve energy: the primary energy consumed to generate electricity is simply divided by 2. While in the thermal powerplants more then 60 percent of the fuel's energy is discharged into the environment, here it is directly used to satisfy the needs for heat.

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POLICIES, PROSPECTS FOR DEEP SEA TECHNOLOGY IN EIGHTIES

Paris L'INDUSTRIE DU PETROLE in French Jan-Feb 79 pp 31-39

[Article by Yves Naudin: "France and the Oceans"]

[Text] Within ten years France has made great strides in the ocean exploitation field and large-scale schemes are under way at the present time. By 1982 a manned vessel designed by CNEXO will be capable of covering 97% of the oceans to depths of 5000 meters. Next year an unmanned underwater craft will carry out its first tests at a depth of 6000 meters. The "deep sea beds" program is progressing according to schedule and new campaigns are planned within the VIIth Plan to try out the existing equipment.

Sea bed mineral resources, which cannot be exploited before 1990, are getting support from the governmental authorities. French organizations are participating in many exploitation projects ranging over the fields of granulates, placers, metal-bearing muds or polymetallic nodules. Finally, the sea's thermal energy may be usable in the future in the intertropical zones. Two industrial groups are to present feasibility studies for the building of a 3000 kW sea thermal energy power station for 1979.

The renewed pursuit of ocean exploitation was officially announced by Andre Giraud, minister of industry, at the Council of Ministers of 15 November 1978. While this decision came as something of a surprise to the petroleum industry, it was received with satisfaction by CNEXO: for this organization, the recent governmental measures constitute a form of moral support and an encouragement to the pursuit of efforts in the field of deep sea bed penetration.

In the areas of sea bed intervention, hydrocarbon exploitation, mineral resources, or utilization of thermal energy, France has acquired in 10 years a certain amount of experience and technological advance over a number of industrialized countries. While it has been proven that offshore oil will play a major role in the future and that ocean mineral resources will lend themselves to long range exploitation, it is now important to know whether

this advance can be maintained. There is no lack of financial means in action since in 1978, about 560 M Fr in public funds, or 3% of the total civilian research and development budget, was allocated to ocean science. Doubtless this total of 560 M seems trivial when compared to the 3600 M Fr budgeted by the US, but it slightly exceeds the civilian budgets of the FRG, Japan, and England.

In France, research is basically financed by general research funds through ocean science funds (350 M Fr in 1978). The rest comes from non-industrial funds budgeted by various organizations and administrations, but earmarked for ocean science research.

Activities of CNEXO

With a budget of nearly 200 M Fr, the CNEXO plays a decisive part in the ocean science program. It is a public institution with industrial and commercial attributes, whose basic function is to coordinate scientific and technological efforts, and to prepare industry to take charge of developing marine resources.

When Gerard Piketty became president of CNEXO in January 1978, the establishment was reorganized toward "coordination and harmonization of the efforts of the various organizations working in the field of marine science." In keeping with this, Mr Piketty was asked last December to furnish by April 1979 an intermediate term program of action, defining the priority goals of French marine science research for the next five years.

But the activities which CNEXO began to carry out 10 years ago have constantly yielded significant results.

Manned Vessels

Among the measures proposed by the Ministry of Industry last November, the most dramatic is surely the construction, starting in 1979, of a new manned vessel able to reach a depth of 5000 meters.

This vessel is not intended to replace the Archimede or the Cyana, which are still useful instruments in ocean exploitation. While the Archimede remains the only vessel in the world capable of reaching the greatest depths (11,000 meters), the Cyana is equally useful for scientific observation and for certain sea bed operations. However, these vessels go back to 1960 and 1963 respectively, and in order for France to keep its technological advance, it has been deemed necessary to develop a new vessel.

The Cyana 5000, whose construction is planned for 1979, should be operational before 1982. Reaching 5000 meters, the capsule will then be able to cover 97% of the oceans. It will also be available for exploration tasks with industrial applications.

Unmanned Vessels

Simultaneously with manned underwater craft, unmanned vessels (towed or self-propelled) continue to be developed at CNEXO.

These two types of craft are obviously complementary. Towed or self-propelled vessels provide rapid and inexpensive surveying of the zone to be explored, by establishing various parameters characterizing the area. By contrast, manned vessels are reserved for activity in a more defined location, when human observation and intervention prove necessary.

Among unmanned underwater craft, there are towed vessels and remote control wireless robots. Belonging to the first of these groups are the Raie 1 with electric cable, and the Raie 2 with purely towing cable, designed to facilitate the exploration of polymetallic nodule deposits.

But the second generation of cable-less unmanned vessels is represented by the Epaulard, designed in 1976, whose first tests at 6000 meters will take place in the spring of 1979. This three-ton vessel, self-sufficient on the sea floor for eight hours, can cover 30-kilometer missions. Since its course and speed are remote-controlled, it can photograph the sea beds and measure their microrelief.

However, the Epaulard will only be able to explore fields at constant altitude, and there is growing urgency for developing a new vehicle able to operate in zones of variable altitude. Project Orque is therefore under study, and its development is planned for 1980. Unlike the Epaulard, Orque will be equipped with a television camera and will transmit its data in real time through direct acoustical link with the surface. While it is true that its field depth will be lower (1000 m), it will on the one hand be able to perform bathymetry and inspection tasks on petroleum or marine installations, while on the other hand it will be able to operate in zones of variable altitude.

Manned Diving

In the field of manned diving, while France holds the world record for open water diving at 501 meters since October 1977, studies are now oriented toward perfecting existing systems.

Since Janus IV, efforts are being concentrated on security, on pushing back the physiological and human engineering limits of operational dives, or else on obtaining better economic conditions.

Related Equipment

The CNEXO program devotes a lot of attention to related equipment. Studies on underwater vessels imply perfecting their instrumentation as well as surface vessels.

Preliminary surveying of terrain by multi-beam detection was successfully tried out during the Vema operations at the end of 1977. Installed aboard the oceanographic vessel Jean Charcot, the Sea Beam was used uninterruptedly for the first time over all the large ocean domains: ridges, fracture zones, abyssal plains, and continental shelves. This system made it possible to draw a real-time morphologic map of a corridor along the route of the vessel, over a width equal to three-quarters of the water's depth.

Two procedures have been developed for locating either surface or underwater vessels. The first of these, developed in collaboration by Thomson CSF and CERTSM, consists of a long, high-precision Navis-Autocal base, covering a broad zone. Location is achieved with respect to a beacon field. The second procedure, formulated with CIT-Alcatel, consists of a system of short bases, with a shorter range. In this case vessels are located with respect to the ship. For underwater vessels, CNEXO opted for perfecting non-linear acoustic sediment probes, which should also make it possible to detect buried lines. Development of high-definition, lateral sweep sonars is also under discussion. These would make it possible to establish a true sea floor map, and in the case of nodules, to continuously determine their density.

Deep Sea Petroleum

To carry out this program of deep sea bed exploitation, CNEXO must periodically consult IFP (French Petroleum Institute) and CEPM (Committee for Marine Petroleum Studies), in order to coordinate its efforts with scientific and petroleum needs. However there is some disenchantment among the latter interests, and Elf and CFP regularly draw the attention of the administration to the inadequacy of financial means made available to them for oil exploration. Mr Dupouy-Camet, CFP exploitation director, went so far as to threaten, last July: "New developments in prospecting require a financial strength which CFP no longer has, and if no changes are made in this respect, we would be forced to withdraw from prospecting at great depths as well as in Arctic zones, leaving the field open to the major American oil companies."

In response, and observing that offshore petroleum exploitation has been positive on the whole, Mr Giraud decided last November to support the deep sea bed program. Undertaken in 1975, this program aims to endow French enterprises with the equipment needed for prospecting and production at sea depths of the order of 1000 meters.

The Offshore Wager

This readiness on the part of the government is inspired by several factors. In the first place, CFP and SNEA are now thoroughly experienced in underwater hydrocarbons exploitation: in 1977, 45% of their exploration efforts were conducted offshore. Furthermore, the French parapetroleum sector must

pursue its technological research if it wants to remain at the forefront of the world market. In this way, it will always be possible to adapt these techniques to shallower depths, of the order of 100 meters, therefore making them rapidly operational.

However, there are occasional instances of reticence or cases of powerlessness. The service industries are in a bad position, and very few industrialists expect a recovery before the next year or two. Until then investors must regain confidence. The only remedy is the discovery of important new deposits. It is therefore necessary to be realistic, to deal with what is most urgent, and to prospect in zones which are the most likely to become rapidly profitable, such as the North Sea, or Latin America.

Thirteen years after the establishment of CEPM, the record of the French offshore petroleum industry is particularly positive. It is true that the financial support for marine studies as a whole has gone from 13 M Fr in 1963 to 360 M Fr for 1977. The state provides 30% of this figure, the balance coming from interested organizations, which are primarily the oil companies.

The deep sea bed program, initiated four years ago, is proceeding according to initial plans.

Drilling

The first drillings at depths of 1000 meters, performed in 1977, have enabled petroleum workers to perfect their techniques in this area. Early in 1977, using the Pelerin dynamic-positioning vessel, CFP performed an initial drilling, Mabibas 1, under 925 meters of water off the coast of Algeria. More recently, in December 1978, CFP repeated its performance under 960 meters of water in the Mediterranean, still using the Pelerin. The tests, which concerned an extension pipe, the Matra measurement coupling, and the Thomson-CSF re-entry sonar, made it possible on one hand to verify the operation of the equipment under normal conditions, and on the other hand to observe the behavior of the extension pipe during disconnection. In the meantime, SNEA has also drilled under 600 meters of water using the ship Petrel.

Therefore, several vessels are already capable of drilling at great depths. However, the market is not huge, and production lead is such that there seems to be no need to further pursue this work at present.

Production

Significant progress in production was achieved in 1977 when an experimental underwater station was placed in service at the Grondin field off the Gabon coast. These tests once more confirmed technical mastery regarding wellheads, safety plugs, risers, connections, and remote control. However, weather conditions make all sea operations difficult and costly. Thus, a new

project is planned in the Mediterranean for 1980, at an average depth of 400 meters, far from the coastline. The work will be concerned primarily with underwater connections and wellhead couplings.

Pipelines

In March 1978, CFP, Elf, and Comex successfully made two Weldap atmospheric pressure welds under 260 meters of water, off the coast of Norway. While this achievement opens the way for repairs on large-diameter pipelines, the technology involved in operations preliminary to welding require additional study. The Seventh Plan also provides for new operations with initial semi-industrial experiments at 300 meters. As for hyperbar welding, it has been fully operational since the Frigg lines were laid in 1976-1977, also it is impracticable at greater depths.

At the same time, other procedures for laying pipe continue to be entirely satisfactory: conventional method at less than 300 meters, RAT method at intermediate depths, and J-method beyond that. In this connection, IFP and Coflexip are conducting studies of flexible lines, notably in terms of the operational range of various diameters and configurations. So far, all the possibilities for utilizing flexible lines have not been exhausted. One possibility being considered in particular is their use together with floating supports, a solution which offers the advantage of being inexpensive.

Finally, IFP is pursuing several long-term research projects, such as the identification of new materials with a density lower than that of steel. Another example is the development of remote-control drilling, being studied in collaboration with SNEA (P). Eventually it will be possible to undertake horizontal drilling. However, this activity is being seriously held back by the problem of improving remote control.

The Arctic As Well

Another promising aspect of French offshore activities is prospecting in Arctic zones. Since 1968, CFP has participated in research in Labrador, using its dynamic-positioning vessel, the Pelican. About 10 wells have been drilled in recent years, leading to three discoveries of hydrocarbons, two in 1974 and one in 1976. In practical terms, the problems are similar to those of deep sea beds. However, additional difficulties are created by icebergs which drift along unpredictable courses. What is even more serious is that they scrape the sea floors and damage existing installations. CFP is considering various solutions: encasing the icebergs in concrete coffers, and burying wellheads and joints. In economic terms, one must also consider weather conditions which restrict arctic exploitation to six months out of the year. Furthermore, while many zones appear interesting because their floors do not go beyond 200 meters, the first meters to be drilled are covered with large stone boulders which make it difficult to pierce the soil. Tests are therefore planned on land, with soils possessing the same characteristics.

In spite of this intense activity, which gives the impression of great vitality, the offshore industry appears to have reached a dead end. The oil companies, in the grip of increasing financial difficulties, are finding it very difficult to maintain their lead in the technological field. Equipment suppliers, of whom there is a surplus as a result of the scarcity of orders, are reluctantly considering reconversion. Faced with runaway foreign competition, they are still hoping for a prompt recovery. The French offshore sector, looking for respite, no longer believes in anything other than external aid to keep it from going under: help from the state.

Underwater Mineral Resources

Underwater mineral research, which is also receiving government support, is in its infancy. While its prospects are still poorly defined, its future appears to hold promise for France. Prospecting efforts are multiplying in the Pacific Ocean, and several industrial projects are under study.

Granulates

Granulates (sands and gravels) are the easiest substances to exploit and have consequently been under study at CNEXO since 1968. In 1971, with the particular assistance of the Bureau of Geological and Mining Exploration (BRGM), CNEXO drew up an inventory of potential resources off the coast of Brittany. These are estimated at nearly 20 Gm^3 of granulates, at depths of 10 to 90 meters, extending from the North Sea to the Gironde. Our country is already extracting, on a small private scale, nearly 3 M Fr of sea sand per year, but reduced industrial activity threatens to significantly slow down the exploitation of these minerals in the next few years, especially since the particularly high cost of production does not encourage industrialists to undertake overly hazardous ventures.

Placers

Continental plateaus also contain large quantities of placers. Here again research is expensive and needs are limited. France, which intends to maintain a leading role in this sector, has organized since 1971 numerous information projects in Australia, Japan, the Philippines, and South East Asia. In Senegal, a search for ilmenite led to the perfecting of tooling and methods necessary for placer exploitation.

In a more general way, French activities in placer research are being conducted at three levels:

Analytically, preliminary studies make it possible to accurately determine zones for prospecting and methods to be used;

Technically, new tooling is designed in order to facilitate ocean mining exploitation;

Operationally, pilot projects are carried out in previously defined zones.

Metal-Bearing Muds

Concerning metal-bearing muds, the most important operations are taking place on the Red Sea, where BRGM exercises a limited role as consultant and advisor. Some twenty trenches about 2500 m deep have been located by the Red Sea Commission, established in 1974 by Saudi Arabia and the Sudan. The Argas/CGG Company and the German company Preussag were involved in this project. At the beginning of this year, research has been conducted from the mining vessel Sedco 445 and the oceanographic vessel Valdivia. This multinational project, receiving huge financial support, should in time enable coastal countries to develop a large market in raw materials. However, the profitability of these deposits remains uncertain.

Polymetallic Nodules

Similarly, the industrial exploitation of polymetallic nodules is not foreseable at present, in spite of earnest efforts made in France by AFERNOD (French Association for the Study and Research of Polymetallic Nodules) since 1974. This organization, born of an agreement between CNEXO, AEC, SLN, France-Dunkerque, and BRGM, is already achieving notable success in spite of competition from powerful international consortiums. Several projects have been carried out in French Polynesia, followed by the North Pacific between the Clarion and Clipperton fractures. In this zone, over 2 million km^2 have been prospected and some 3500 samples have been collected. After preliminary research in two phases, optimal zones over an area of 100,000 km^2 were identified: they are believed to hold more than 900 M t of wet nodules with a combined nickel and copper content of 2.6%.

However, detailed exploration is necessary, in order to determine content as well as to evaluate the abundance of nodules. Some of the methods which could be used are acoustical location, dredges, cameras and photographic equipment mounted on cable-drawn vehicles, or lateral-sweep sonar. Several types of vessels are being studied in France. Scheduled to become operational in a year or two, they will have the drawback of slow reconnoitering speed, insofar as the dredging of a few hundred meters will require about seven hours.

It is difficult to determine the cost of these operations because many parameters are unknown: the location of the processing plant, actual capacity of a collection unit, extraction process, and so on. For an annual exploitation of 3 M t of nodules at depths of 5000 meters, investment costs are estimated at a minimum of 5 G Fr, a figure which in any case is certainly well below the actual one.

A Promising Industry

Whether it is a matter of granulates, placers, metal-bearing muds, or polymetallic nodules, France intends to pursue its prospecting efforts. But no industrial project is planned before the 1990's. It is tempting to draw comparisons with the offshore oil industry, especially since it is generally felt that the mining industry's present situation is similar to that of the offshore industry 15 or 20 years ago. In many respects, the methods and techniques used in these two fields are similar, which is one more reason to further encourage an industry which is still marginal and costly but full of promise.

Thermal Energy of the Oceans

In the context of mastery of the sea, marine thermal energy can also benefit from all the recent technological know-how acquired in offshore oil exploitation. The earliest efforts in this area go back to d'Arsonval and more recently to Georges Claude, who failed in their day for technological and financial reasons.

Principle of a Plant

A marine thermal energy (ETM) plant makes use of the natural temperature difference that exists in intertropical zones, between the warm water at the surface and the cold water below. This difference, which can reach 20 to 25 °C, is utilized in a thermal machine through a thermodynamic cycle which can be either open or closed.

In open circuit, the warm sea water is contained at very low pressure. Brought to the boiling point, it is then sent through a turbine and condensed in the cold water. In closed circuit, the warm water is brought into a heat exchanger where it gives up its heat to an intermediate fluid such as ammonia, which boils at very low temperature. In the first case, a high-power turbine must be used; in the second, the heat exchangers have to be very large. In addition, in both processes, one-third of the power produced is used to supply auxiliary installations.

Pilot Unit in 1983

Well aware of these problems, CNEXO therefore recently asked two industrial groups to formulate two study contracts for the feasibility of an ETM plant. One of these groups, composed of CGE, Alsthom-Atlantique, and ETPM, will concentrate on the installation of an open-type plant on a floating platform. The other group, led by Creusot-Loire and France-Dunkerque, will study a land-based plant which uses the ammonia closed circuit.

These studies must be presented at the end of 1979, at which time a decision will be made concerning the construction of a small 3000 kW installation. If results are conclusive, the pilot unit could be operational in 1983-1984 at a cost of 100 M Fr. Tahiti has been selected as the probable site.

In any event, ETM plants can only make a small contribution to our energy balance, since their use is limited to intertropical zones. Thus most of the Overseas Territories and Departments are interested in these plans (West Indies, Polynesia, New Caledonia, and Reunion). This form of power should become profitable in less than 10 years.

Foreign Achievements

Abroad, only the USA and Japan have turned to marine thermal energy. Their programs are much more ambitious than the French one. As early as 1982, the Americans will test a 10 MW floating pilot plant, followed by a 25 MW unit, and will eventually instal a first 100 MW demonstration plant around 1985. They have adopted the high-power, closed cycle, floating plant system. In the year 2000, they plan to instal 20 GW, which is equivalent to one percent of American electric power consumption. The budget allocated to this research is naturally considerable: $600 million between now and 1985, or 20% of the amount set aside for solar energy.

Japan's awakening has been slower, since the first serious studies date back to 1976. A pilot unit of 10 to 25 MW should be in operation by 1989, when 100 MW commercial plants will take its place.

Tomorrow the Sea

In September 1978, after establishing the Interministerial Sea Mission, the government decided that "adaptation of the Seventh Plan will be marked by a major ocean exploitation project." The first steps announced by Andre Giraud a few weeks later confirmed this intention. However, it is still too early to estimate the consequences of this enormous scientific and technical effort.

Moreover, the formation of the 200 nautical mile Exclusive Economic Zones (ZEE) endows France, thanks to its Overseas Territories and Departments, with an 11 M km^2 marine area, placing it third after the USA and England. The equipment needed for observation and surveillance of ZEE now remain to be determined. Here once more, the creation of an industry for equipping these zones should provide France with a sizable market for exporting its technology.

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SECONDARY RECOVERY BY SEAWATER DISCUSSED

Paris L'INDUSTRIE DU PETROLE in French Jan-Feb 79 pp 83-86

[Article by Georges Djiniadhis and Andre Ohanian, Managers, Guigues SA: Seawater Injection into Offshore Oil Fields]

[Text] In the normal evolution of oil field production characteristics it turns out that their productive capacity falls with the well head pressure.

In order to keep this pressure up and/or carry out secondary recovery of the oil contained in the reservoir rock, operators are increasingly resorting to physical methods aimed at helping the oil to leave the reservoir.

The methods generally consist in injecting a fluid into the reservoir; this may be water, natural gas, carbon dioxide gas, etc., alone or in a combined system.

In offshore fields water is generally chosen for the injection fluid owing to:

--its availability in adequate amounts,

--its effectiveness in displacing oil,

--its zero raw material cost.

Although seawater has been shown for many years to be a satisfactory fluid in this area, its injection into oil deposits has still met with problems.

Preliminary Tests

Whenever seawater injection into an oil field is contemplated it is essential to ascertain a number of the physico-chemical characteristics of:

--the seawater itself;
--the field water;
--the extracted gas; and
--the structure of the reservoir rock.

Each test is of particular interest and permits the planning of the treatment installations and additional conditioning treatments.

Seawater Analysis

Conducted on samples taken at different depths; they permit the determination of the optimum pumping depth.

The determination of the break point permits ascertaining the chlorine feeds to avoid equipment fouling.

Break Point Definition

The break point corresponds to the minimum amount of chlorine in the curve, for which no more chlorine addition compounds are present in the water.

Principle

Determine by the orthotolidine method the residual chlorine in a series of flasks containing the water to be purified and an increasing quantity of chlorine solution, e.g., Javel water. The resulting curve passes through a minimum which corresponds to the break point or critical point.

Reactants

Chlorine solution prepared from commercial Javel water titrating 1 ml = 0.1 mg/l (the chlorometry of commercial Javel water is normally 48°, i.e., about 150 g/l Cl_2; and 0.1% orthotolidine solution.

Operating Method

Introduce 100 ml of the water to be purified into a series of numbered stoppered flasks.

Add into each flask with a set of calibrated pipets increasing amounts of chlorine solution. Seal hermetically.

Leave in contact for 30 minutes, agitating at the beginning, in the middle, and at the end of the experiment.

Add 10 ml 0.1% orthotolidine solution. Agitate.

Allow to stand 5 minutes and conduct the spectrophotometric measurements at 440 nm wavelength.

Expression of the Results

Construct the residual chlorine content curve as a function of the chlorine solution added to each flask.

The curve passes through a minimum for one of the flasks. The minimum corresponds to the break point.

Analysis of the Field Water

A knowledge of the quality of the field water will permit the determination of its compatibility with the injection water, and the possible introduction of one or more additional conditioning treatments.

Extracted Gas Analysis

A knowledge of the CO_2 and H_2S contents in the extracted gas will permit the consideration or exclusion of its use as stripping fluid.

Reservoir Rock Structure Test

A knowledge of the porosity and permeability of the reservoir rock will permit the calculation of the fineness necessary to avoid clogging in the immediate vicinity of the injection well.

Seawater Treatment for the Purpose of Injection

Preliminary studies having resulted in a number of hypotheses and the seawater properties have been well determined, the treatment installations and the conditioning products which would provide for the operation of the injection system unit with minimum risk must be specified.

Generally, they consist in:

--Chlorinating the seawater at the sampling point;

--Prefiltering and/or filtering;

--Lowering the dissolved oxygen content;

--Injecting scale and/or corrosion inhibitors; and

--Injecting bactericides.

Seawater Chlorination

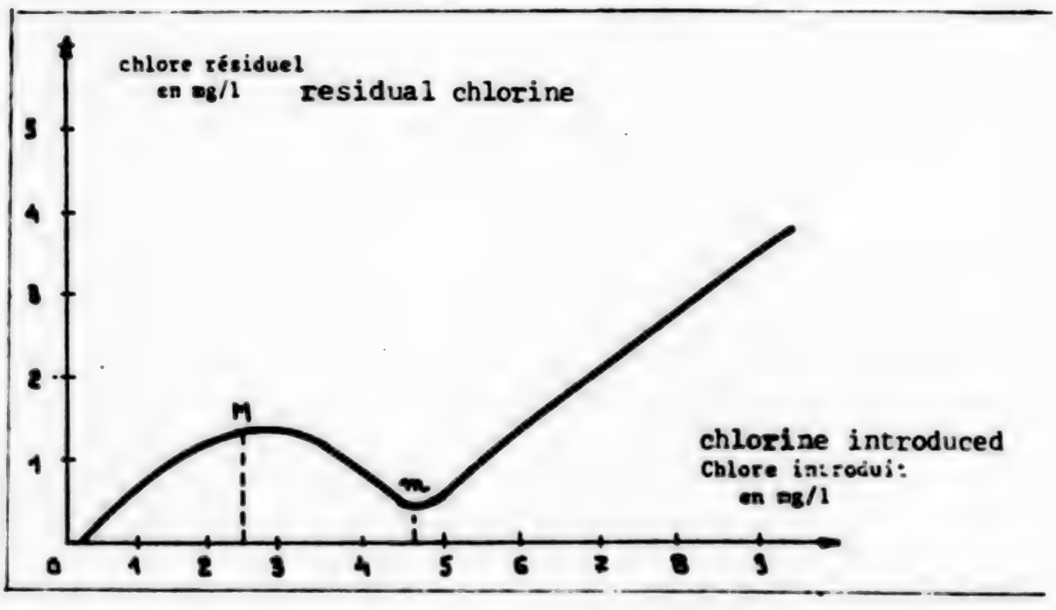
The presence of microorganisms in seawater entails risks of fouling in the low pressure section of the installation. To avoid fouling, or at least limit it to an industrially acceptable value, an antifouling product must be injected.

Among the commercial products of this type, chlorine is still the most commonly used, and may be employed:

--in gaseous form, subject to the difficulty of storage, supply, and application implied by this reactant; or

--in hypochlorite solution form obtained by direct electrolysis of seawater. The latter technique is used more and more for reasons of safety, simplicty and control.

The chlorine or the hypochlorite solution necessarily must be injected at the level of the seawater feed pump intake screens, in a quantity sufficient to maintain a residual content of Cl_2 of about 0.5 mgl after filtration.



m corresponds to an initial amount characterising the critical point or break point
The curve representing chlorine (residual), plotted against the chlorine introduced, rises beyond the critical point along a straight line of slope 1
The dissolved oxygen content will permit the determination of the deoxidation treatment.

Filtration

The purpose of filtration is to eliminate most of the suspended materials contained in the water, in order to provide it with properties compatible with that of the reservoir rock.

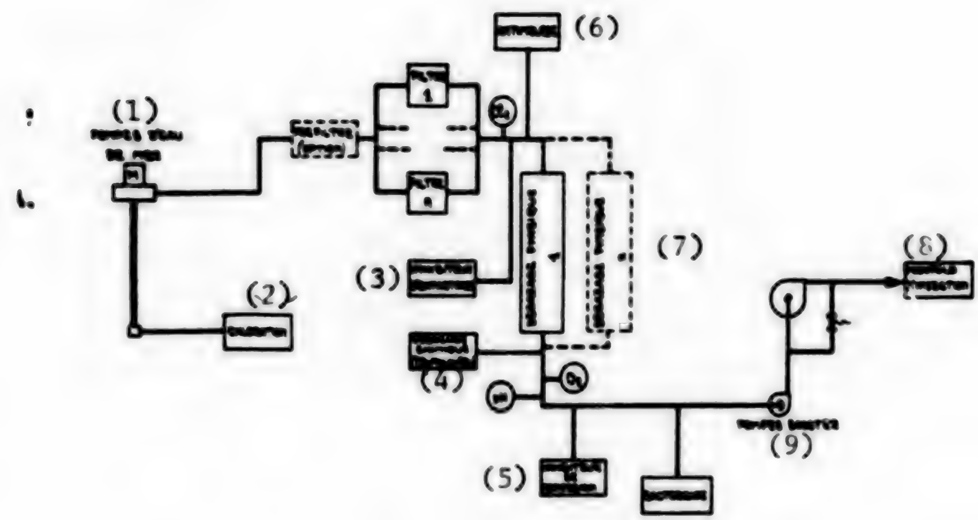
This operation is conducted generally in closed filters whose active charge (sand or anthracite) is of appropriate granulometry. In sand beds the filtration rate may reach 7 m^3/m^2/hr.

The filters are washed with:

--filtered water alone (American practice); or

--air and water (European technique).

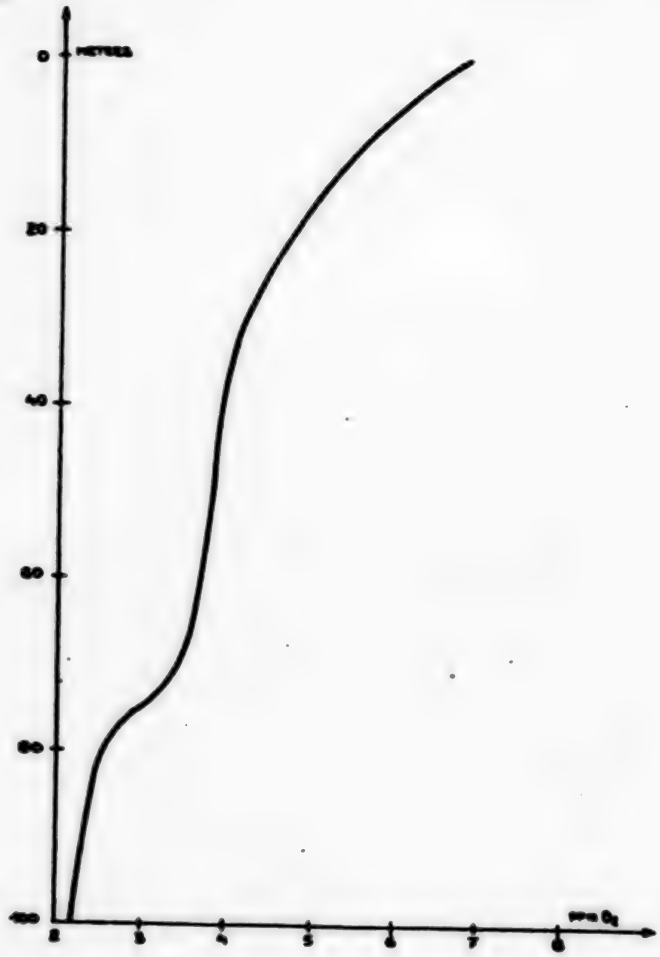
The desired fineness of filtration is related to the porosity and permeability of the reservoir rock. However, most operators are in agreement to require a filtration fineness of 10 microns. When the seawater contains large particles in suspension, the primary filtering operation may be facilitated by prefiltration, using an automatic-cleaning mechanical filter.



Typical diagram of a seawater treatment installation

Key:

1. seawater pumps
2. chlorination
3. scale inhibitor
4. chemical degasing
5. corrosion inhibitor
6. antifoam
7. physical degasing
8. injection manifold
9. booster pumps



Gradient of oxygen dissolved in seawater (Likouala, Congo)

Lowering of the Dissolved Oxygen Content

Since oxygen is one of the agents responsible for corrosion, its concentration must be lowered to a value ranging between 0.02 and 0.04 ppm.

A physical process and/or a chemical process can be used for this purpose.

Since seawater contains an average of 6-8 ppm of oxygen (see for example the dissolved oxygen gradient curve for Likouala, Congo, seawater), its total elimination by chemical methods would require large amounts of reducing agent. Therefore, physical degassing must be effected, and completed chemically to remain within acceptable cost limits.

Physical degassing can be conducted according to two main methods:

--Vacuum degassing; or

--Strip degassing with natural or inert gas.

The choice between the two processes depends substantially on local conditions:

--Availability of natural gas free of H_2S; or

--Possibility to prepare inert gas from combustion gas from internal combustion engines located in the vicinity.

However, it should be observed that physical degassing may entail two major risks:

$CaCO_3$ precipitation resulting from a fraction of the equilibrium CO_2 during the treatment. This must be prevented by injecting a scale inhibitor upstream of the degassing unit; and

Foaming in the degassing columns, due primarily to the presence of surface active substances. To avoid this disadvantage an antifoam agent must be injected upstream of the degasifier. The last traces of oxygen are eliminated at the degasifier outlet by injection of sodium sulfite in the proportion of 10 ppm Na_2SO_3 per mg/l residual O_2.

Subsequent to this treatment the water treated by this method is:

--Stored in a tank; or

--Directly injected into the field.

Additional Treatments

After the different preliminary treatments seawater has some physico-chemical properties whose knowledge will permit the introduction of the additional treatments necessary to avoid--or at least limit to industrially acceptable values--the different types of corrosion, viz.:

Chemical corrosion due to the presence of gas (CO_2, H_2S) dissolved in the water;

Electrochemical corrosion; and

Bacterial corrosion by sulfate reducing bacteria.

Corrosion is to be avoided or limited by the addition of corrosion inhibitors such as:

Neutralizing amine;

Film-forming amine; or

Imidazoline, etc.

Bacterial development will be controlled by injection of a suitable bactericide.

To obtain the best guarantees for this treatment the inhibitors must be injected either continuously or in shock amounts alternating at a frequency to be determined in situ.

9456
CSO: 3102

INDUSTRIAL USE OF SUGAR BEET ALCOHOL DISCUSSED

Paris LE NOUVEL ECONOMISTE in French 17 Sep 79 pp 48-49

/Text/ Mr Henri Cayre, the restless boss of the sugar beet industry, has a solution for decreasing oil imports: "Why doesn't the chemical industry use our sugar beet alcohol instead of synthetic alcohol obtained by hydration of ethylene?" Price increases determined by OPEC countries, he said, could make this substitution profitable in 2 or 3 years. Today, synthetic alcohol used in "chemical reactions"--essentially for the production of plastic materials--is sold for 178 francs per hectoliter by the Service of Alcohol.

Synthetic alcohol is produced in only one factory, SODES (Societe d'ethanol de synthese) near Tancarville. Shareholders: Thone-Poulenc, Ugine-Kuhlmann and SFECI...an agricultural group with Mr Cayre as president, which joined the two chemical groups in 1966 "as an experiment."

As for sugar beet alcohol, it has a guaranteed price backed by the EEC at 286 francs the hectoliter. Produced by 23 independent distilleries and 14 sugar plant-distilleries--which also produce alcohol from molasses--it serves at present only for "reserved uses": food, perfumes, pharmaceuticals, vinegar.

At least a 100-franc difference exists between the two. But this difference has not stopped decreasing: synthetic alcohol went from 145 francs the hectoliter in January to 178 francs 1 April, and the recent increases in oil will cause another price jump. Better still: the energy total clearly favors sugar beet alcohol. Synthetic alcohol "burns" 3.2 calories to produce one; sugar beet alcohol requires only 1.3.

Thus Mr Cayre's idea is simple. For the moment, the EEC fixes quotas on the production of sugar beet alcohol by "guaranteeing" a quota A: the producers are assured that its sale price will not fall below 286 francs. Why not create a supplementary quota, a guarantee of only about 200 francs, which would serve for industrial use?

Although tempting, Mr Cayre's idea creates two problems:

--France is far from lacking agricultural alcohol to denature for industrial use; it is glutted with it, since too often inferior wines from Languedoc must be distilled. The cost for the community is not negligeable. Will it be again necessary to increase the stocks?

--For producing his alcohol, Mr Cayre would like to expand sugar beet cultivation to at least 50,000 hectares. But, to avoid the transporation of sugar beets--costly as it is--from one region to another, it would be necessary to increase cereal growing areas near the existing distilleries. A difficult measure to pass, when distillation alcohol is overabundant. Of course, an alcohol of inferior quality can be produced from molasses, a by-product of sugar. However, the quantities of molases are insignificant with respect to the industrial investment which would be necessary. And increasing the production of sugar is unthinkable: the EEC is sinking under 3 million excess tons of sugar which it must export to world markets at half the cost price.

The minister of economics, aware of the energy requirements of the operation, and the minister of agriculture have only to think about the propositions of the sugarbeet industry. They will certainly become interesting, as soon as the problem of the distilleries in Languedoc is solved: The industry consumes 3.5 million tons of alcohol. Producing it from sugar beets would mean that the capacities of existing distilleries would have to be doubled. And that SODES would have to be closed without dramatic repercussions from the 150 people it now employes.

9128
CSO: 3102

BRIEFS

SOLAR ENERGY COMMISSION BIDS ON BIOMASS--In August, the Solar Energy Commission issued an invitation for bids for studies on biomass and energy. The candidates, namely industrial researchers and interested utilizers, have until 12 October to submit their proposals in the following areas: resources, agricultural and forest by-products, wastes from the lumber and agricultural industries, algae, conversion technologies, fermentation, thermo-chemical conversion, final utilization of energy, fundamental studies on bioconversion from solar energy. The administration decided to focus on biomass last February. This sector receives endowments of 15,000 f which should be doubled next year. According to some estimates, by the year 2000, solar energy will represent about 17,000 tep of the total French energy and biomass should contribute up to 5,000 tep. /Text/ /Paris SEMAINE DE L'ENERGIE in French 13 Sep 79 p 19/ 9128

CSO: 3102

CHARACTERISTICS OF NEW ELECTRIC VEHICLE OUTLINED

Turin ATA in Italian No 6, Jun 79 p 251

[Article: "A Proposed Alternative: the Electric Vehicle"]

[Text] At a time when the problem of reducing fuel consumption is of greater interests than ever, IVECO presents a vehicle using alternative energy: the Daily electric-traction van, with storage batteries, built for the purpose of showing the possibility of producing an electric vehicle in parallel with an internal-combustion engine vehicle, of whose mechanical organs it retains a large part.

The electric engine is mounted in the place of the diesel engine and is coupled to the gear box, which, however, is fixed at the reduction ration of 2.04:1; the rest of the transmission is the normal installation. The batteries are housed in boxes for the purposes, mounted under the chassis, and can be removed for inspection; filling with distilled water is done through a centralized system.

Speed is controlled through a normal accelerator which commands an electronic regulator; this device provides very precise speed regulation, and when the accelerator pedal is released while the vehicle is in motion, it switches in an electrical braking system with current recovery (the current being restored to the batteries). When the brake pedal is actuated, the electrical braking action is intensified first, and in the second phase of the pedal's travel, the hydraulic brakes also are applied, on the wheels.

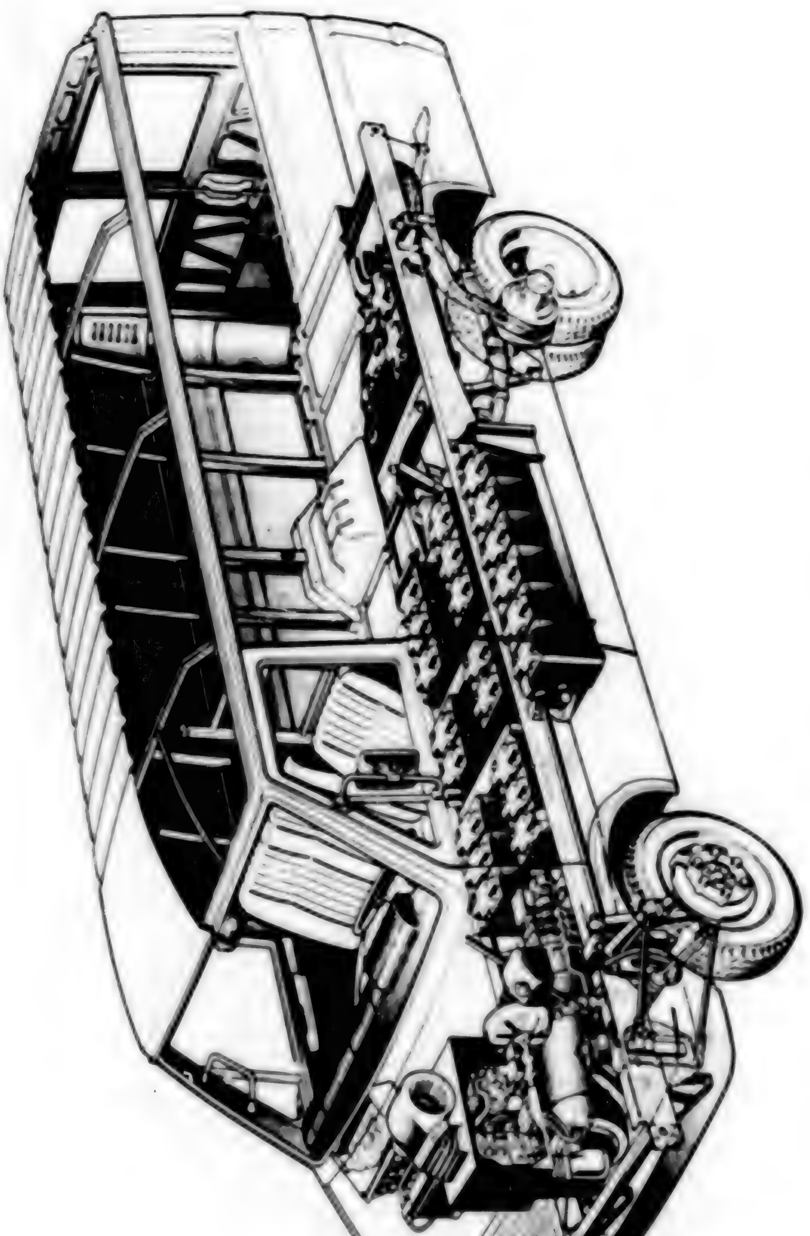
A series of safety devices protects users from every possible breakdown or dangerous situation: for example, the batteries are in groups of elements whose voltage is never higher than 60 volts. With the vehicle stopped and engine off, a parking device, in addition to the normal hand brake, blocks the transmission mechanically to make the vehicle itself immobile. A device is also provided which acts on the traction plant to limit maximum speed to whatever values may be prescribed for urban districts.

The mechanical characteristics of the electric vehicle are those common to the Daily-Grintas--that is, front wheels with independent suspension, front power disc brakes. It also has an independent diesel-fuel heating system for cold climates, and a ventilating system.

Because of the fact that the batteries are installed under the chassis, the entire interior of the vehicle is available for load-hauling, or for passengers, in the case of the passenger version.

Driving the electric Daily presents no difficulties; in fact, it could be said to be quite a bit easier than driving a conventional vehicle, inasmuch as it does not have a clutch pedal or gear-shift lever. The driver has only to accelerate and brake with the pedals for those purposes, and reverse is operated by a switch that changes the direction of rotation of the motor.

The prototype has been presented in France to the interministerial group that intends to promote the diffusion of this type of means of transport and has carried out practical tests at the research center of Electricite de France [French National Electric (Power) Company], the French equivalent of the ENEL [National Electric Power Agency].



FIAT Daily-Grinta With Electric Propulsion

11267
CSO: 3102

PROPOSALS FOR 'HYBRID' VEHICLES EVALUATED

Turin ATA in Italian No 6, Jun 79 pp 267-275

[Article by L. Morello, L. Ippolito, and R. Piccolo, of FIAT Research Center at Orbassano (Torino): "FIAT Research Center's Prototype of Hybrid Vehicle"]

[Text] 1. Introduction

Within the framework of the research being carried on around the world with the object of reducing the fuel consumption of automotive vehicles can be included the research program of the FIAT Research Center (CRF) on hybrid propulsion systems.

Various considerations work in favor of this type of system and make it of interest for the future development of transport systems.

In a conventional vehicle, the average efficiency of use of the thermal energy available is 0.16, on an FUDC (Federal Urban Driving Cycle) course.

Detailed analysis of the various phases of the cycle shows that the energy spent during the vehicle's forward-motion phases is only 84 percent of the total amount of energy put out by the thermal engine; the remaining 16 percent is dissipated in the passive phases (deceleration 9 percent, and 7 percent while the vehicle is stopped and idling) (Table I).

TABLE I. Energy Consumption of a 3,000-pound Vehicle through the FUDC Cycle

Length of course	11.4 miles
Duration of course	31' 17"
Total energy to wheels	9.21×10^6 (J)
Total energy to thermal-engine shaft	10.47×10^6 (J)
Total thermal energy	56.4×10^6 (J)
Total energy consumed in acceleration	23.5×10^6 (J)
Total energy consumed through aerodynamic resistance	9.2×10^6 (J)
Total energy consumed through rolling friction	12.0×10^6 (J)
Thermal energy dissipated during braking	6.1×10^6 (J)
Thermal energy dissipated in idling	5.6×10^6 (J)
Energy dissipated in the brakes	4.2×10^6 (J)

In addition, the braking phases cause the dissipation, in the form of heat, of the kinetic energy accumulated by the vehicle.

On the basis of the above, it can be stated that a prime way of reducing fuel consumption consists in better exploitation of the thermal power during the stopped and deceleration phases.

A hybrid system meets this requirement, since it is flexible enough to permit shutting-off of the motor while the vehicle is stopped and it is also capable of storing up kinetic energy during deceleration.

A second consideration that can be made for the traditional type of propulsion system is the following: on the average in an urban cycle, the thermal engine supplies power with a mean specific consumption of 475 g/kWh, while the traditional engines have zones in which their specific consumption is $\approx$ 270 g/kWh or less.

It is thus obvious that a second means of reducing fuel consumption is to couple the thermal engine better with the wheels (for example, with electronically controlled continuous transmissions) [1]. The hybrid system, by its very characteristics, is capable of putting out maximum power that varies little with vehicle speed (except, of course, for the start-up phase), because of which it can be likened to a traditional thermal engine.

Moreover, the hybrid propulsion system is a double fuel-supply system, and therefore, preponderant use of one energy source over the other, and vice-versa, can be considered for different vehicle uses. For example, use of the vehicle in urban centers, at low speed and with constant stopping, with the thermal engine turned off, can be considered; this makes for reduction of pollution in the zones with heaviest traffic, through reduction of emissions and noise.

On the basis of what has been explained, the CRF has initiated a research program for study of hybrid propulsion systems that utilize as the second energy source both energy of a mechanical type and energy of an electrical type.

From this point on, what has been done and what will be done in future in the field of electrical hybrid systems will be analyzed, with reference to the CRF's research program.

The analysis has been limited to those system configurations considered valid for the short and medium terms, and a study of them through the use of mathematical simulation models worked out on computers has been initiated.

The results of this study have led to construction of a first prototype, for the purpose of confirming experimentally the results calculated previously.

The experimental tests, already carried out in part, have confirmed the validity of the methods adopted in the simulation of the various systems.

The future program provides for completion of the experimental tests, aimed essentially at measuring the burned-gas emissions, and construction of a second prototype (second generation), with an electronic control system added.

It should be noted that the main objective which the CRF has set itself in its research on hybrids is to minimize fuel consumption, with the batteries considered not as a second energy source but as a means of storing kinetic braking energy and to smoothe out the power-demand peaks during the use of the vehicle.

This way of posing the problem is obviously very different from that of reducing fuel consumption partially at the cost of the electrical energy stored in the batteries.

2. Alternative Possibilities in Designing an Electrical Hybrid System

The problems presented in designing an electrical-hybrid system are many, and sometimes connected with the type of application decided on beforehand.

Above all, there is the problem of choosing between a series type or a parallel type of configuration; the distinction between the two types of system is based on the distribution of the energy flows within the system itself (Figure 1). In particular, in a series type of system, all of the thermal power is transformed into electric power, and propulsion is obtained only through an electrical machine, while in a parallel-type system, not necessarily all of the thermal power is transformed into electric power, but part or all of it can reach the wheels mechanically and directly.

Moreover, while the series approach makes it possible to disengage the propulsion system completely from the wheels, the parallel system maintains a mechanical link between them.

From the energy point of view, the parallel system proves more promising, inasmuch as only part of the thermal energy produced is transformed into electric power, with consequent energy degradation.

Work previously done by the CRF for application of a hybrid propulsion system to an urban-type bus has made it possible to confirm the above.

Finally, the parallel-type system requires the use of one less electrical machine by comparison with the series-type system, and requires lower nominal power, inasmuch as traction is also furnished by the thermal part of the system, with consequent reduction of weight and bulk.

On the basis of these considerations, the CRF has gone ahead with research on hybrid applications in the automobile field, adopting the parallel-type approach; indeed, the problem of the bulk and weight of the propulsion system proves to be of prime importance in a passenger vehicle.

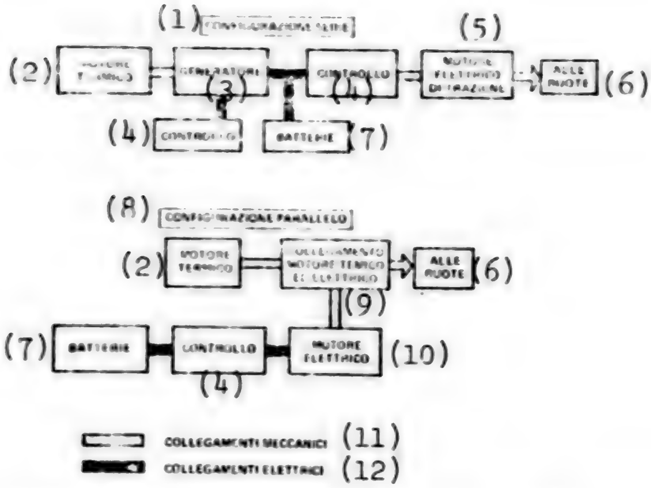


Figure 1. Conceptual diagrams of electrical-hybrid propulsion system--
series and parallel configurations.

Key:

1. Series configuration
2. Thermal engine
3. Generator
4. Control
5. Electric traction motor
6. To the wheels
7. Batteries
8. Parallel configuration
9. Connection of thermal and electric engines
10. Electric motor
11. Mechanical connections
12. Electrical connections

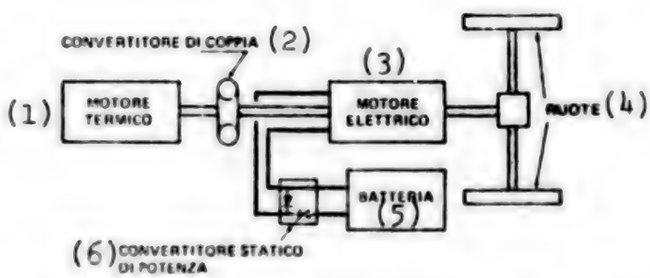


Figure 2. Diagram of parallel-type hybrid system adopted on FIAT 131 prototype

Key:

1. Thermal engine
2. Torque converter
3. Electric motor
4. Wheels
5. Battery
6. Static power converter

It must also be kept in mind that once the system's configuration has been defined, there are still many possibilities for different approaches, depending on the components used and the control logic of the system adopted.

The simplest conceivable system is composed of a thermal engine, torque converter and electric motor in line, connected to the wheels through a transmission shaft (Figure 2); any other alternative requires the use of clutches to couple the various machines, with the necessity, therefore, of using actuators to operate them and an auxiliary control unit to automate the functioning of the system.

The solution presented in Figure 2 (which was adopted on the 131 prototype) lends itself to construction without an auxiliary unit for system control on condition that the power of the thermal engine is sufficiently low. In fact, the control logic is already inherent in the mechanical command of the accelerator: with short pedal travel, the energy required comes solely from the thermal engine functioning at wide butterfly-valve openings (hence with good efficiency); with further pedal travel, the electric motor cuts in too, thus furnishing power only at the peaks. In braking, the electric motor, functioning as a generator, recharges the batteries.

This sytem, not equipped with a central control unit, is not capable of taking account of the state of charge of the batteries. The values calculated with the mathematical model make it possible to state that this propulsion system applied to a 131 automobile is capable of reducing fuel consumption by about 18 percent on the FUDC course (by comparison with a normal production-model 131 vehicle) with light battery discharge.

With reference to this cycle, the overall energy saving is on the order of 13 percent.

Table II presents the comparative data for the two vehicles.

The simplicity of contruction of this type of system, taken together with the considerable saving of fuel, are the main reasons that led to choosing this configuration for the experimental vehicle built.

The configuration of a parallel-type system turns out quite different when the possibility exists of managing the system through an auxiliary control unit (Figure 3). It should be noted in particular that the two machines--thermal engine and electric motor--are in a side-by-side position, so as to have two independent routes for transferring power to the wheels.

In this type of solution, the thermal power is disengaged from that required at the wheels, and is that which corresponds to the minimum-consumption curve. The power at the wheels is obtained by adding the necessary electric power algebraically.

There are three fundamental conditions for the functioning of the system:

(a) use in very slow urban traffic with frequent braking: the vehicle functions electrically only; the thermal engine is disconnected and turned off;

(b) normal urban and suburban use: starting-up is done electrically, and when thermal-engine coupling speed is reached, the system functions as a hybrid;

(c) extraurban use at constant speed (highway): with desired speed reached, the system functions as a conventional automobile.

TABLE II. Comparison of Performance and Fuel Consumption between Reference Vehicle and Hybrid Vehicle on the FUDC Course

Vehicle Type	Data	Performance			Fuel Consumption		
		Max. Speed (km/hr)	400 m (sec)	1,000 m (sec)	Gasoline (liters/ 100 km)	Electrical Energy (amp-hr)	Total (liters/ 100 km)
FIAT 131 1,600 cc	Experimental	--	--	--	9.9	--	9.9
	Calculated	157	20.6	37.8	9.4	--	9.4
Hybrid Type A (calculated vehicle)	Experimental	--	--	--	--	--	--
	Calculated	122	21.1	39.7	7.7	1.02	8.14
Hybrid Type B (vehicle built)	Experimental	120	24	44	10.3	1.7	11
	Calculated	122	23.5	42.1	9.4	1.6	10.1
Hybrid Type C (electronic control)	Experimental	--	--	--	--	--	--
	Calculated	133	22.6	42.8	7.06	--	7.06

The results calculated for this type of system applied to a 131 automobile lead one to predict a fuel-consumption reduction on the order of 20 perent to 30 percent by comparison with the conventional model of equal performance characteristics, with the state of charge of the batteries kept unchanged (Table II).

In fact, the control logic of this system has been designed in such a way as to conserve the electrical energy stored in the batteries.

The two solutions examined above represent the simplest and one of the most complex hybrid systems examined by the CRF; other solutions have been examined, with results falling inbetween the two.

On the basis of the studies reported above, and in order to keep to the program's time schedules, the CRF decided to build the first prototype, adopting the parallel solution without electronic control system.

3. Mathematical Model

The main objective of the mathematical model consists in simulation of a sufficiently broad number of propulsion systems, obtainable by combination of basic components, for the purpose of evaluating fuel consumption and emissions through a generic cycle.

The course is normally defined through a law that specifies vehicle speed in function of time.

Secondary objectives are calculation of consumption at constant speed and calculation of the vehicle's curve of acceleration.

To simplify calculation, the transitional phases have been described through a series of stationary states.

Comparison between calculated results and experimental results has in many cases confirmed the validity of this simplification.

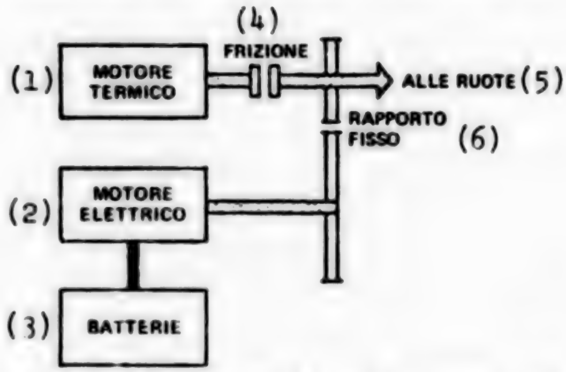


Figure 3. Diagram of Parallel-Type Hybrid System with Electronic Control

Key:

1.	Thermal engine	4.	Clutch
2.	Electric motor	5.	To the wheels
3.	Batteries	6.	Fixed ratio

3.1 Analysis of Components

Thermal Engine--For the purposes of these analyses, the thermal engine is considered to be represented sufficiently by the graph of fuel consumption relating to the bench-testing under stationary conditions (Figure 4). On this hypothesis, calculation of consumption is done by means of a plane interpolation which uses engine power and RPM as input parameters and gives specific consumption as output.

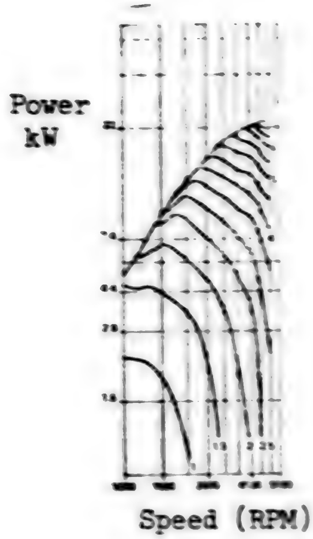


Figure 4. Graph of Consumption (kg per hour) of a Thermal Engine

DC Electric Machine--The DC electric machine has reversible operation, as is known, and can thus be used both as a motor and as a generator.

Figure 5 shows a typical graph of the efficiency of a DC machine with mixed excitation.

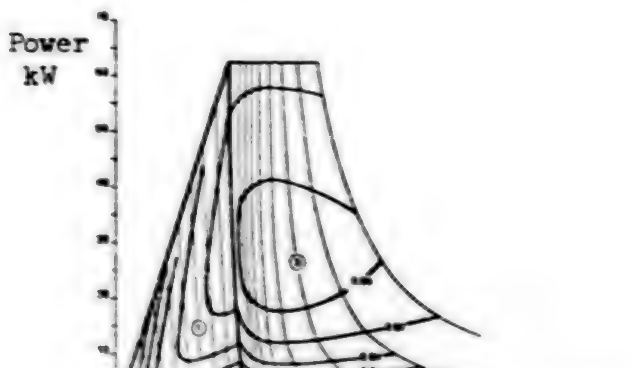


Figure 5. Graph of Efficiency of a Direct-Current Electric Machine

Areas 3 and 4 of Figure 5 are coverable by regulation of excitation current; but areas 1 and 2 require the intervention of the armature chopper.

The purpose of the model is to define a functional relation of the type:

$$\eta = F\ (P_m,\ n,\ V_b) \tag{1}$$

in which:

η = efficiency of the machine

P_m = mechanical power required

n = machine shaft revolutions

V_b = power-supply voltage.

The objective is achieved by using the equivalent electrical circuit of the machine and calculating the losses by the formulas commonly used in the designing of electrical machines [2, 3, 4]. Figure 6 is a schematic diagram of the electronic converter (chopper) used for regulation of the machine.

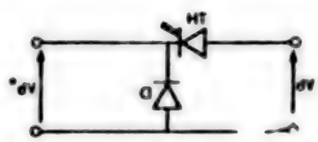


Figure 6. Functional Diagram of the Static Power Converter

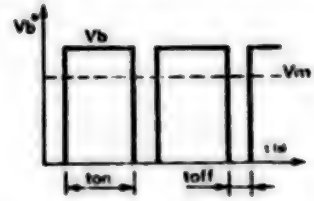


Figure 7. Output Voltage from Static Power Converter

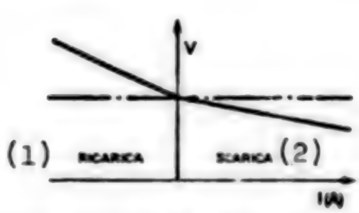


Figure 8. Characteristic Voltage-Amperage of a Battery

Key: 1. Recharging 2. Discharging

The output voltage V_b^* is represented in Figure 7.

The mean value V_m of the voltage depends on the conduction time of the thyristor TH in relation to the overall period of functioning of the chopper.

Therefore:

$$V_m = K\ V_b \tag{2}$$

With:

$$K = \frac{t_{on}}{t_{on} + t_{off}} \tag{3}$$

Batteries--Simulation of batteries under generic operating conditions is a problem of considerable complexity that has not yet been solved satisfactorily.

Analysis is complicated by the fact that the characteristics (voltage-amperage) of the batteries are strongly influenced by their state of charge; nevertheless, in cases in which it is permissible to suppose that the level of charge is not far off the initial level, the characteristic of the batteries can be represented by means of a break defined by two different values of slope, for recharging and discharge, respectively (Figure 8).

The preceding hypothesis would obviously prove too simplistic if one wanted to analyze operating cycles including heavy discharges (electric automobiles); for these cases, other mathematical models [5] have been worked out, and the reader is referred to them.

Gear Change--The gear change, understood as speed varier, is a dissipative system whose efficiency can be expressed in function of the transmission ratio, the load, and the RPM of the drive shaft (Figure 9). Since in general the power and the RPM on the driven shaft are known, and the same magnitudes are sought for the drive shaft, the calculation is done by the iterative method, starting from an initial efficiency value and gradually correcting it through successive interpolations.

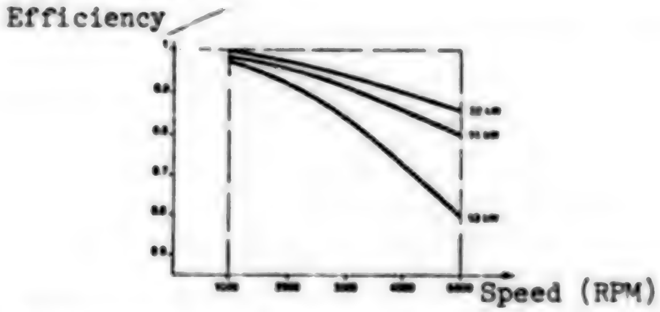


Figure 9. Efficiency of a Transmission in 4th Speed

Clutch and Torque Converter--Analysis of these components can now be considered sufficiently standardized; therefore, the information necessary for doing a simulation can be found in the most authoritative texts [6, 7].

3.2 Calculation Procedure

In many cases, the course on which it is desired to calculate consumption and emissions is specified by points; the time interval (T) is usually constant and equal to 1 second.

Therefore, with the speeds fixed for the beginning and the end of the interval indicated by V_i and V_f, respectively, the vehicle's mean acceleration is defined by the relation:

$$a_m = \frac{V_f - V_i}{\Delta T} \tag{4}$$

The power required at the propulsor set must verify the equation:

$$(P_1\eta_1 + P_2\eta_2) = P_{acc} + P_{aer} + P_{rot} \tag{5}$$

in which:

P_{aer} = power needed for overcoming aerodynamic resistance

P_{rot} = power needed for overcoming rolling resistance

P_{acc} = power needed for accelerating vehicle

= power supplied by propulsor 1

= power supplied by propulsor 2

η_1 = efficiency of transmission of power P_1

η_2 = efficiency of transmission of power P_2

In addition, if we indicate the vehicle's apparent traveling mass as M, we can write:

$$P_{acc} = Ma_m \cdot V_m \tag{6}$$

or:

$$P_{acc} = M\left(\frac{V_f - V_i}{\Delta T}\right)\left(\frac{V_f + V_i}{2}\right)$$

$$P_{acc} = \frac{M}{2\Delta T}(V_f^2 - V_i^2) = (\tfrac{1}{2}MV_f^2 - \tfrac{1}{2}MV_i^2)\frac{1}{\Delta T} = \frac{\Delta t}{\Delta T} \tag{7}$$

ΔE being the variation of kinetic energy of the vehicle in the time interval considered.

The passive resistances can be expressed as functions of the vehicle speed V and of the loads by the following formulas:

Rolling Power:

$$P_{rot} = (\Sigma_i \; f_i \; Q_i) \; V \; (i = 1.2) \tag{8}$$

with:

$$f_i = F(k_i, Q, k \; P_i, V) \tag{9}$$

definitions: k_i = coefficient taking tire type into account

Q_i = axle load

P_i = tire pressure

Aerodynamic Resistance:

$$P_{aer} = 1/2 pAC_x V^3 \tag{10}$$

definitions: A = frontal section of vehicle

C_x = coefficient of aerodynamic penetration

p = air density

Averaging in interval T, one has:

$$P_{aer} = 1/2[(P_{aer})\ v = v_i + (P_{aer})\ v = v_f] \tag{11}$$

$$P_{rot} = 1/2[(P_{rot})\ v = v_i + (P_{rot})\ v = v_f] \tag{12}$$

In cases of systems with a single propulsor, equation (1) makes it possible to determine immediately the power that must be furnished to the vehicle by the engine; in the hybrid systems, though, the distribution of power between the two propulsors can be done in many ways.

From this consideration arises the necessity of defining a logic for management of the installed power, or an arbitrary law for the supplying of energy.

A simple way of resolving the problem consists in defining one of the two propulsors as the priority one, making full use of its availability, and using the other to cover peak power needs.

However, many other ways of proceeding are possible. With the values of P_1 and P_2 defined in this way, it is possible to define completely the conditions of functioning of the two machines in accordance with what was presented in the analysis of the components.

Finally, the the vehicle's performance characteristics are determined by integrating the equation of motion:

$$M\frac{dv}{dt}V = (P_1\eta_1 + P_2\eta_2) - P_{aer} - P_{rot} \tag{13}$$

in which P_1 and P_2 indicate the curves of maximum power of the two propulsors in compatibility with the preselected management logic.

In some cases (presence of a torque converter - startup by means of clutch) the equations of motion also change because of the disconnection between the

drive shaft and the driven shaft necessitated by these components; the system of differential equations that derives from them is integrated by the Runge-Kutta method of the 4th order and with an integration pitch of at least 0.01 second.

3.3 Calculation Program

The mathematical model was implemented in a computer, with an effort made to adhere to the following specifications:

(a) modular construction, to permit analysis of many systems;

(b) flexibility of use, for data input in particular;

(c) possibility of monitoring the evolution of the various individual parameters during the cycle;

(d) creation of a series of libraries for storing the characteristic data of the various individual components;

(e) simplicity of use.

Special importance was also assigned to definition of the management logics of the various individual systems, for the purpose of providing a sufficiently complete instrument of calculation.

4. Parametric Study of the Parallel-Type Hybrid System of the 131 Prototype

The optimization possibilities offered by a hybrid lacking an auxiliary control unit are very limited. The mechanical arrangement of the components (Figure 2) imposes, by its nature, precise limits both on the choice of the parameters useful for optimization of the system and on the choice of the management logic.

If the thermal propulsor is taken as the priority one, and the electric propulsor is used to meet peak power requirements, a first parameter results that is distinctly characterized in terms of installed thermal power.

In this hypothesis, it is supposed that the electric motor is of such dimensions that it always meets the power requirements; however, the necessity of limiting the weight and bulk of the batteries can lead to possible reductions of the electric power available.

Furthermore, for better adaptation of the installed power to the power required by the course, it can be useful to analyze the influence of the differential reduction ration on the vehicle's fuel consumption and performance.

In this regard, Figure 10 illustrates, for the vehicle examined and for the FUDC course, the variation of the specific energy (thermal + electric) in function of the two parameters individuated.

On the basis of this analysis it proves possible to choose the thermal power and the differential reduction ratio in such a way as to reach a good compromise between reduction of fuel consumption and maintenance of acceptable performance characteristics and range.

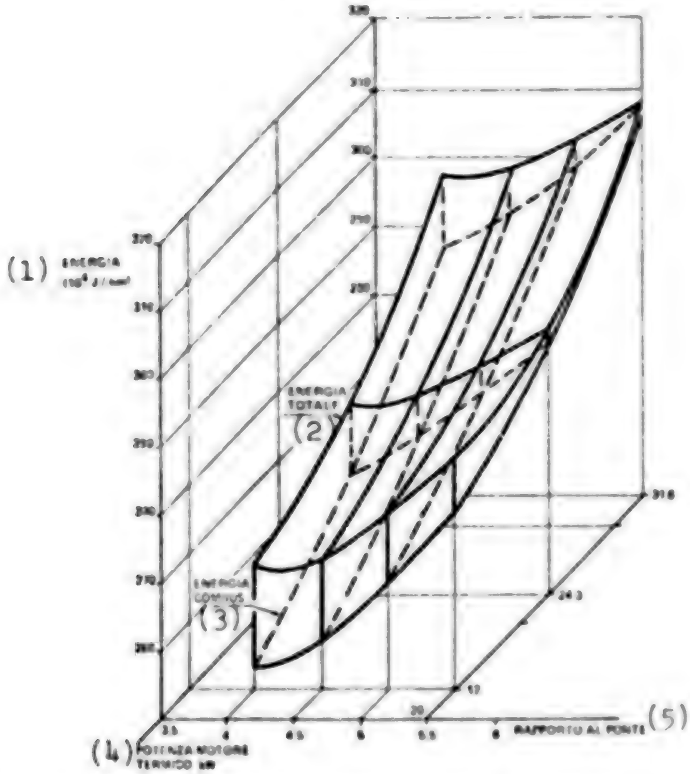


Figure 10. Energy Consumption on FUDC Cycle by FIAT 131 Parallel-Type Hybrid Vehicle

Key:

1. Energy
2. Total energy
3. Combustion energy
4. Thermal engine power in kilowatts
5. Ratio at rear end

But a system like that illustrated in Figure 3 presents greater possibilities of analysis and makes it possible to use a larger number of parameters for optimization of the system itself.

5. Description of Prototype

The project specifications were defined in consequence of the parametric study carried out on the hybrid propulsion system applied to the FIAT model 131.

The propulsion system (Figures 11a and 11b) is composed of a 24.3-kW gasoline-powered thermal engine coupled with the 20 kW-nominal DC electric motor (of the type normally used on electric vehicles by the FIAT SpA [Inc] Research

Center) through an 8.5" torque converter with lock-up clutch. The ratio of the differential, defined in the parametric study, turned out to be 4.44:1 (teeth ratio).

Taking into account the fact that the electric motor is capable, under overload, of putting out $\approx$ 40 kW peak power, the vehicle's performance characteristics as shown in Table II (Vehicle A) were deduced by calculation.

During the phase of designing the system and building it into the automobile, it became necessary to give in to some compromises in construction, in order to have the prototype ready for the tests by the dates set.

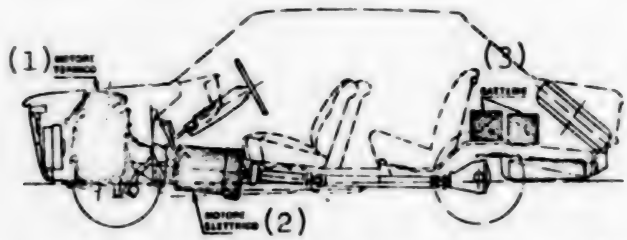


Figure 11a. Diagram of FIAT 131 Parallel-Type Hybrid Automobile

Key:
1. Thermal engine 2. Electric motor 3. Batteries

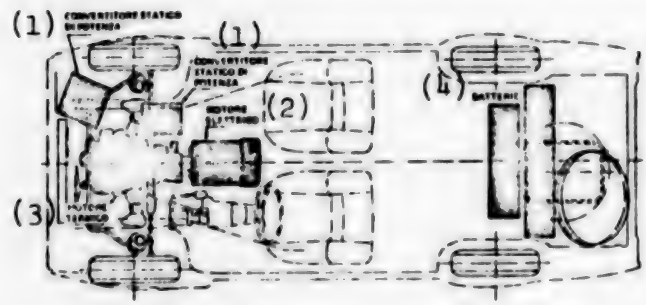


Figure 11b. Diagram of FIAT 131 Parallel-Type Hybrid Automobile

Key:
1. Static power converter
2. Electric motor
3. Thermal engine
4. Batteries

The unavailability of a 500-A static power converter for regulation of the electric motor led to choosing another static converter, of 250 A (with consequent reduced electric power available).

The same kind of thing happened with the 8.5" torque converter with lock-up clutch, which was substituted for by an 8" converter without lock-up clutch. In the calculation of the system, the maximum braking current was hypothetically assumed to be 100 A, while in reality, the peak recovery current had to be limited to 70 A. In addition, the calculation provided for braking with

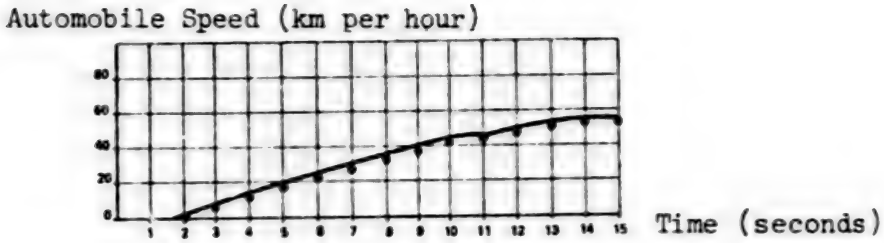


Figure 12. Comparison between Calculated and Experimental (Continuous Line) Values during a Vehicle Speed Acceleration Phase in Function of Time

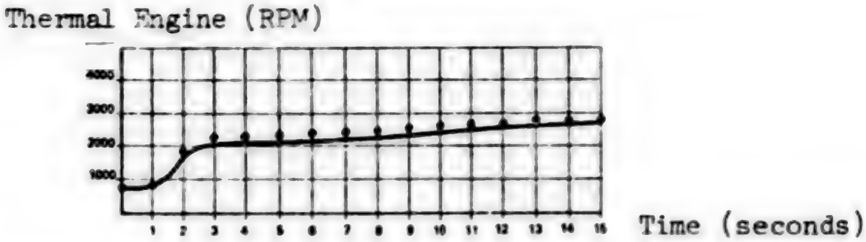


Figure 13. Comparison between Calculated and Experimental (Continuous Line) Values during a Phase of Thermal Engine Speed Acceleration in Function of Time

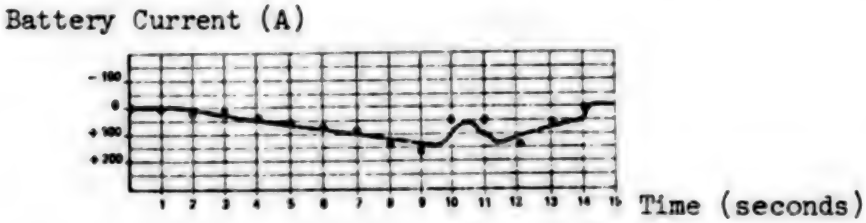


Figure 14. Comparison between Calculated and Experimental (Continuous Line) Values during a Battery-Current Acceleration Phase in Function of Time

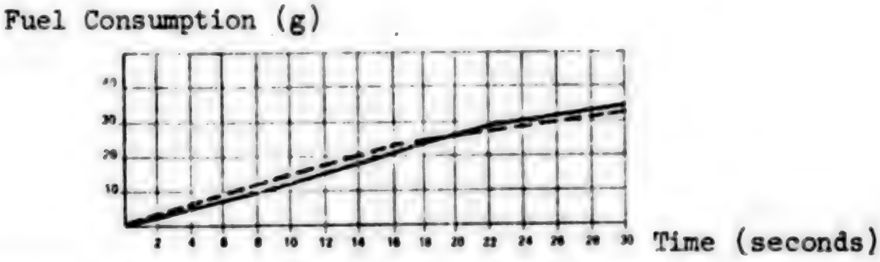


Figure 15. Comparison between Calculated and Experimental (Continuous Line) Values during a Fuel Consumption Acceleration Phase in Function of Time

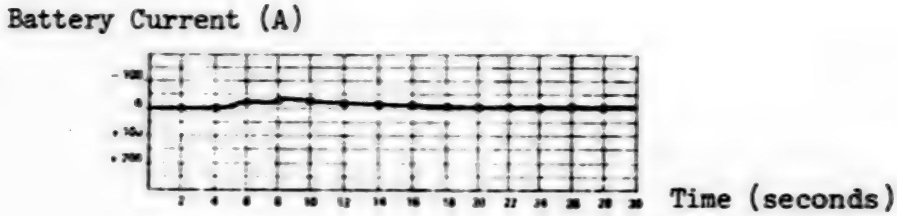


Figure 16. Comparison between Calculated and Experimental (Continuous Line) Values during a Battery-Current Braking Phase in Function of Time

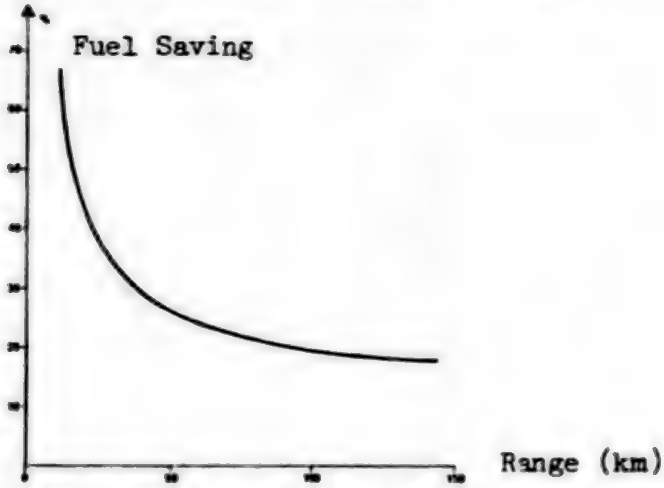


Figure 17. Fuel Saving in Function of Range

current continually variable in function of braking couple, while the prototype has two fixed levels, at 30 A and 70 A.

On the basis of the above, it is obvious that the vehicle built offers performance characteristics and fuel consumption different from what was calculated; Tables II and III present the comparative data as between the hypothesized vehicle (Hybrid Type A) and the vehicle actually built (Hybrid Type B). Nevertheless, the necessity of validating the mathematical model led to acceptance of the limitations imposed by the time schedule.

6. Experimental Tests

The experimental tests carried out so far have had the objective of verifying experimentally the values calculated--both performance values (acceleration and maximum speed) and values of fuel consumption (both of combustible fuel and electrical energy) in the FUDC cycle.

In Figures 12, 13 and 14, the experimental values (continuous line) are compared with the calculated values, for several significant magnitudes of the vehicle (automobile speed, thermal engine RPM, battery current) in an accel-

eration phase on the FUDC course. Figure 15, on the other hand, shows fuel consumption in the same phase; and Figure 16 presents the battery current in a braking phase--still on the FUDC course.

The figures presented above testify to the validity of the CRF's mathematical model, not only as regards overall estimation of consumption of gasoline and electrical energy in the cycle but also in following, step by step, the evolution of the principal variables of the system under examination.

TABLE III. Comparison of Hybrid Vehicle Characteristics

Automobile Characteristics	Proposed 131 Hybrid, Type A	131 Hybrid Built, Type B	Hybrid Type C
Weight (2p)	~1,600 (kg)	1,588 (kg)	1,630 (kg)
Max thermal power	24 (kW)	24 (kW)	42 (kW)
Nominal electric power	20 (kW)	20 (kW)	20 (kW)
Max braking current	-100 (A)	-50 (A)	-100 (A)
Max current in traction	+450 (A)	+250 (A)	+450 (A)
Nominal voltage	144 (V)	144 (V)	144 (V)
Braking	continuous	2 levels	continuous
Weight of batteries	182 (kg)	175 (kg)	182 (kg)
Specific power of batteries	220 $(\frac{W}{kg})$	220 $(\frac{W}{kg})$	220 $(\frac{W}{kg})$
Torque converter	8-1/2" with lock-up	8"	none
Static power converter	controlled diodes	controlled diodes	transistor
Reduction ratio between electric motor and thermal engine	1	1	1.273

TABLE IV. Experimental Values of Range

Course	Range
FUDC (11 cycles)	133 km
Center of Turin, on road	161 km

The drivability of the hybrid automobile was evaluated with satisfactory results, especially during the range tests, which were carried out in the urban center of Turin. Table IV presents the data relative to this testing.

The results reported above take into account consumption both of combustible fuel and of electrical energy, expressed in coherent units. Figure 17, on the other hand, shows the saving of fuel in function of the daily range required on the assumption of complete discharge of the batteries every day.

If this range is not more than 20 km, the fuel saving rises to $\approx$ 45 percent.

The choice between the two possible alternatives is linked to the price of gasoline and of electrical energy and to the optimization of energy sources.

7. Conclusions

Even if the results obtained from the tests carried out on the 131 prototype are of slim absolute value, they have been extremely useful in validating the mathematical model. On the basis of the experience required, one may reasonably expect to succeed in achieving energy savings on the order of 30 percent with more sophisticated hybrid systems.

If the hybrid system includes a continuous transmission as well, the fuel savings should rise to values around 35 percent without use of the electrical energy stored in the batteries.

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NEW CARBURETOR CONTROL DEVICE TESTED

Turin ATA in Italian No 5, May 79 pp 216-219

[Article by Prof Eng Dino Dini, director of the Institute of Machines and Agrarian Mechanics of the University of Pisa; Dr Eng Giancarlo Nardi, professor of instrumentation and oleodynamic, pneumatic and fluid circuits and assistant professor of machines in the University of Pisa; Dr Eng Salvatore Cicconardi, graduate technician in the Institute of Machines and Agrarian Mechanics of the University of Pisa; Dr Eng Alessandro Argentini, Oto Melara, La Spezia: "Pneumatic Device for Correcting Operation of the Idling Circuit for Carburetors"]

[Text] Introduction

Within the scope of experiments performed for the purpose of limiting the fuel consumption of automobile engines and, at the same time, of lowering the level of concentrations of polluting substances in the exhaust, many experimenters have felt the need for making modifications to mass-produced carburetors.

Therefore, there is a variety of devices produced and marketed for that purpose, like, for example, turbulence generators and mixture diluters.

The device experimented on by us is used to modify operation of the carburation circuit in the idling phase and the driving phase. In fact, during these phases, carburetion is performed by a special circuit, consisting of pipes that appear down from the throttle valve. The air-gasoline mixture is drawn from those pipes owing to the vacuum in the intake manifold. This vacuum varies considerably. In other words, it ranges from values close to atmospheric pressure, with the carburetor throttle valve completely open, to values $\simeq$ 27 kPa under conditions of the engine dragged in deceleration by the automobile. Therefore, since the setting of the carburetor adjustment components remains unchanged (set for idling operation), the amount of mixture induced is not always in accordance with the actual requirement of the engine. Especially, when the engine is dragged by the inertia of the automobile, the idling circuit delivers

an amount of mixture, at times rich in gasoline, that usually burns only partially, resulting in the production of a considerable amount of unburned hydrocarbons.

In addition, the excess gasoline introduced into the engine for long periods, for example during long downgrade runs, causes dilution of the lubricant.

These phenomena that occur both in downgrade running and in the numerous deceleration phases characteristic of city traffic, limit the braking effect of the engine on the automobile when the accelerator is released, in addition to causing a useless waste of fuel.

The most immediate solution for obviating the above-mentioned disadvantages is to adjust the carburetor by blocking the flow of mixture coming from the idling pipe within certain predetermined limits of the value of the vacuum in the intake manifold.

Operation of the Device

The principle of operation of the device experimented on by us stems from an observation of the improper behavior of the idling circuit in one phase of operation of the engine, the release phase.

If the throttle valve closes suddenly at any given speed, a vacuum is created down from the throttle valve, depending on the number of revolutions per minute [rpm] and which is, at any rate, greater at idling speed.

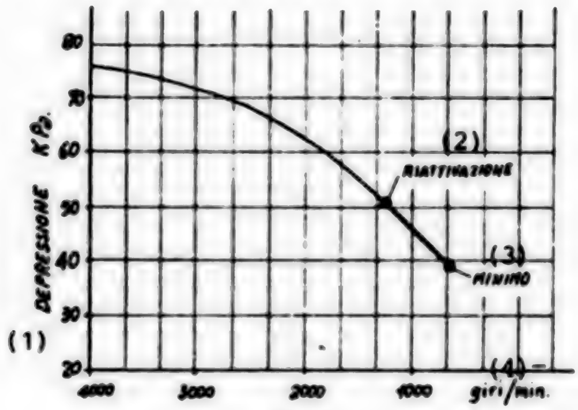

Fig. 1.

Key: 1. vacuum; 2. reactivation; 3. idling; 4. rpm

The chart, figure 1, shows the behavior of vacuum, measured in the deceleration phase for the FIAT 500 used in the tests. The function of the device is to deactivate the idling circuit in the "release" phase.

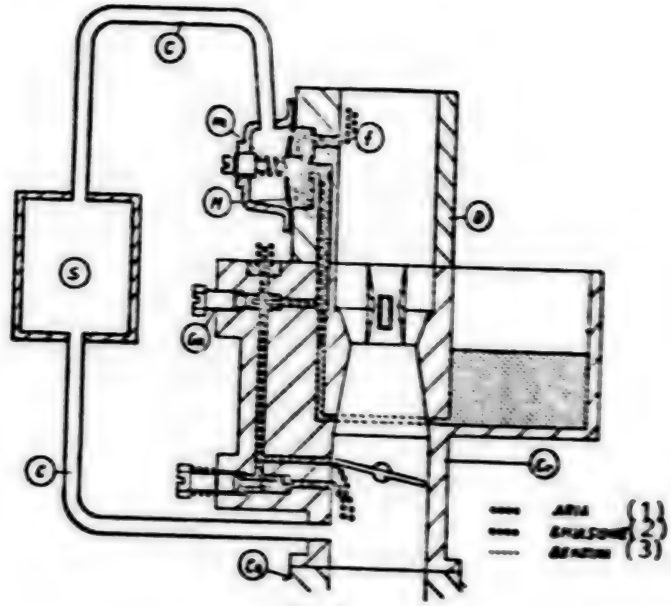

Fig. 2.

Key: 1. air; 2. mixture; 3. gasoline

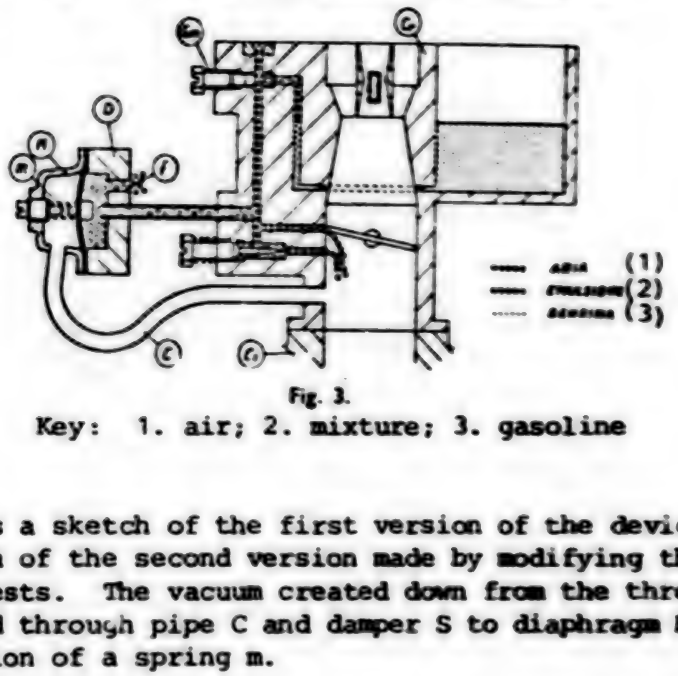

Fig. 3.

Key: 1. air; 2. mixture; 3. gasoline

Figure 2 gives a sketch of the first version of the device and figure 3 gives a sketch of the second version made by modifying the first one after a series of tests. The vacuum created down from the throttle valve is transmitted through pipe C and damper S to diaphragm M, which closes hole f by action of a spring m.

Therefore, the diaphragm is subjected to two forces: F_m due to action of the spring and F_p opposite to F_m due to the pressure difference caused on its faces and proportional to it.

When, as vacuum is increased, F_p exceeds the value of the opposing force, the diaphragm moves and opens hole f.

Thus, the circuit carrying the gasoline to idling jet G_m is connected with the atmosphere. Therefore, there no longer is intake of gasoline, but rather of air.

When the number of engine rpm decreases, vacuum decreases and, therefore, force F_p, which, at a certain speed close to idling speed, is not sufficient to prevent the action of the opposing spring, which closes hole f again by pressing on the diaphragm.

Thus, the idling circuit is reactivated.

It is obvious that by acting on the spring adjustment a more or less delayed reactivation of that circuit is achieved.

The ideal would be, at this point, instantaneous reactivation at idling speed, but that is not possible, because, before reactivation, the idling circuit contains only air and a certain time interval (≃ 1 : 1.5 second) is needed before it fills with mixture again.

In that interval, the engine may die or "hesitate," if the throttle valve is acted on., because the running device is deactivated together with the idling device.

Therefore, reactivation has to take place at ≃ 300 : 500 rpm over idling speed (see chart, figure 1).

By doing this, the field of utilization of the device is closed.

This disadvantage, observed in the experimental phase, was eliminated by making a second version of the device in question (see figure 3). With this version, action is not upstream from idling jet G_m, but rather downstream, precisely close to the running holes. By doing this, mixture flow is interrupted only in a short stretch of the piping.

The inertia of the system, in other words the time taken by the idling pipe to fill with mixture from the moment of its reactivation is practically nothing. In fact, during operation of the engine, the disadvantages encountered in the first version were not observed.

Another difference between the two prototypes is that the first version has a chamber S with damping functions needed for decreasing the periodic irregularity of the vacuum. This phenomenon appears primarily at slow speeds in single-cylinder and two-cylinder engines.

The chamber was eliminated in the second version, because we reazlied that its presence might have contributed to damping the oscillations of the movable parts of the device, but at the same time it might have caused a delay in its activation.

Results of the Tests

In order to evaluate the efficiency of the device, a series of tests were performed on two automobiles differing in number of cylinders, specifically a FIAT 500 and a FIAT 127.

Both vehicles were tested on a roller stand and were subjected to tests in the Europe Cycle. Data were obtained both on pollution and on fuel consumption.

Tables I, II and III give the average of the results obtained by first testing the two automobiles equipped with mass-produced carburetors and then by using the device.

All the comparative tests were conducted under the same environmental conditions.

After the results of the bench tests, it was decided to conduct some on the road, specifically on a run outside the city. Only fuel consumption was observed on those tests.

The results obtained on the road are not as objective as the bench tests, because they are affected too much by changing conditions of temperature, pressure, air humidity between tests, but especially by traffic conditions.

In spite of what is stated above, the road tests served the following purposes:

Confirmation of an actual reduction in consumption.

Value indicating that consumption.

Verification of a greater "engine braking" effect.

Table I: Average Values Derived from a Series of Tests Performed on the Bench (Europe Cycle) on a FIAT 500

	With device inserted	With mass-produced carburetor
Hydrocarbons (ppm)	293.12	401
CO (%)	0.87	1.32
CO_2 (%)	11.11	9.37
Fuel (g)	275	299.25

Table II: Average Values Derived from a Series of Tests Performed on the Bench (Europe Cycle) on a FIAT 127

	With device inserted	With mass-produced carburetor
Hydrocarbons (ppm)	285	406.25
CO (%)	1.1	1.61
CO_2 (%)	10	8.12
Fuel (g)	279	307

Table III: Average Values Derived from a Series of Tests Performed on the Road (on a FIAT 127)

	With device inserted	With mass-produced carburetor
Fuel consumed		
q' (g)	1493.6	1661
q (l)	1.99	2.21
q" (l/10 km)	5.68	6.33
Run (km/l)	17.53	15.76
Time taken (min)	50.33	51
Average speed (km/h)	41.76	41.16

The test run was 35 kilometers, with a maximum gradient of 615 meters.

Figure 4

Figure 5

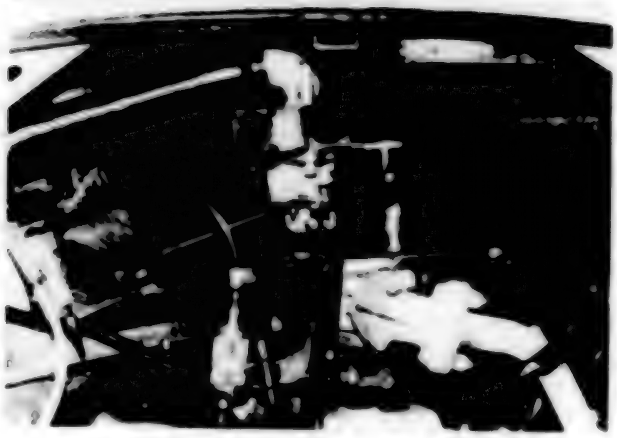

Figure 6

The device, produced in two different versions and mounted on the carburetor, is shown in figures 4 and 5. The engine of vehicle equipped with the modified carburetor can be seen in figure 6. Finally, it was ascertained, during the tests, that, for a special setting condition, the device succeeds not only in correcting the deceleration phase, but also in regulating carburetion automatically during idling, bringing it to lean mixture values.

In fact, it is known that the number of rpm of a engine, at idling speed, depends not only on the amount but also on the composition of the mixture, because of which variations in vacuum in the intake pipe, caused by variations in the number of rpm, act on the correction device, causing variations in the composition of the mixture and producting, as a result, automatic stabilization of the number of rpm and of the composition dosed at high values of the air/gasoline ratio.

In other words, the valve of the device, which opens and closes an auxiliary air-brake with features of a switch (all or nothing) in the accelerator release phase, acts, during the idling phase, in an almost proportional manner, causing a richer or leaner mixture proportional to the value of the vacuum. Therefore, the number of rpm, the vacuum and the composition of the mixture are tied together by a process of automatic adjustment.

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NEW VERSION OF VARIOMATIC AUTO TRANSMISSION DEVELOPED

Frankfurt/Main FRANKFURTER ALLGEMEINE in German 26 Sep 79, p 36

[Text] The oil crisis has forced automobile manufacturers to make their products more economic. Therefore, the automatic transmission had to pass before the magnifying glass of critical analysis. Of the various suggestions for automatic transmissions, only one has been used on a global scale: a combination of hydrodynamic torque converter and outlet-connected, usually three-stage planetary transmission.

There has been no lack of attempts to solve the problem by means of a converter with greatly expanded conversion range (like Hondamatic). But the results were not entirely satisfactory. In addition, the automatic converter does not operate economically--especially when using the "kick-down" for downshifting. The only simple automatic transmission which is attractive from its operating principle was developed by the Dutch van Doorne brothers. They mass-produced it in their small car (the "Daffodil") under the name "Variomatic" at the end of the 1950s. From the Daffodil there developed the DAF and from the DAF the Volvo. The Variomatic is still around but its simple technology has been surpassed.

Since the sale of DAF to Volvo, Hub van Doorne, the inventor of the Variomatic, has been working privately with a small team on a new solution to the problem. The idea of a mechanical torque converter which will transfer the force through the work cycle of an elastic band via two pairs of bevel washers with variable work-cycle radius promised a smoothing of force-transfer stages--these are unavoidable in transmissions with "gears"--in addition to simple design and good mechanical efficiency.

The step to a new beginning was taken in the meantime by the newly founded Van Doorne's Transmissie BV in Tilburg with a so-called "thrust link-belt." In contrast to the V-belt used for the Variomatic, the belt is made of metal and transfers the engine power from the driving to the driven pair of bevel washers through pushing instead of pulling. This represents a package of 10 to 14 rings about 20 mm wide made of strong sheet metal of less than 0.2 mm thickness. These rings or washers are placed one on top of the other and they are highly resistant. The material of these steel washers comes--

like so much else today--from space research. Small steel blocks are lined up on this ring-packet; the conical outer surfaces of these blocks lie against the flanks of the bevel washers.

Presently there are two different designs for thrust link-belts; an older one with the U-shaped thrust-links placed on the ring-packet and held by a pin inserted through their legs, and a second design with side slits in the thrust links into which a small ring packet is inserted on left and right. Power transmission occurs only by the pressure exerted by the thrust links whereas the ring-packet serves only to keep the links in position and to guide the bevel washers precisely.

Torque conversion takes place--just like for the Variomatic--through a change in separation of the movable from the fixed bevel washers (attached to the shaft); this change takes place for the two pairs in opposite directions. Thus the work-cycle radii of the thrust link-belt change inversely. The metal thrust link-belt permits the use of relatviely small work-cycle radii and thus allows a very compact construction of the bevel washer transmission. Bevel washers and thrust link-belt run fully enclosed in an oil bath. Since the thrust links are subject to almost no sliding friction but are addressed primarily by pressure, hardly any wear occurs.

One disadvantage of the bevel washer Variomatic was its large size and the fact that it was therefore not suitable for front-wheel drive. The new Transmatic however, needs no more space than a normal transmission and was designed in Tilburg specifically for front drives. In contrast to the Variomatic, the moving bevel washers are pushed by means of oil pressure delivered by a motor driven by the oil pump. The control hydraulic system is very simple and operates with only two valves. Start-off permits use of a simple centrigugal clutch. From the driven pair of bevel washers the power transmission moves over a reduction gear by which forward or backward driving is selected by a simple operating sleeve.

The first test model was used primarily to check long-term life of the thrust link-belts and has run 150,000 km in city traffic, and even more in some vehicles, without any trouble. Power Transmission of 97 to 98 percent is at a mechanical efficiency matched by no gear transmission. For the complete drive system including reduction transmission and differential, the development director, van der Veen, gives an efficiency of "between 88 and 92 percent." In its test design the Transmatic is about 10 percent lighter than an automatic transmission of standard design. This improvement would be even greater if a die cast metal housing were used. In price the Transmatic would range in the middle, between a five-gear transmission and an automatic--but naturally this will depend on the number manufactured.

We made full use of the Transmatic in city traffic and on the open road in two Ford Fiestas (1.1 and 1.3 liter). The centrifugal clutch engages smoothly at about 1100 RPM and is fully shifted at about 2500 RPM. The transmission is almost noiseless when driving and responds gently to changes in gas-pedal

position. The continuous adjustment of torque to the needed power allows the auto to accelerate more briskly than gear-shift designs. For optimum acceleration the engine stays at its nominal RPM whereas the transmission speed reduction constantly adapts to the driving tempo. For downhill driving there is a pull-knob on the dashboard which permits "downshifting" of the hydraulic system in order to retain the breaking action of the engine.

The fact the Van Doorne Transmatic is generating lively interest in many quarters can be seen from the decision of Fiat and the American Borg-Warner group to participate substantially in the Tilburg Company.

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